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HOLBROOK FITZ JOHN PORTER

AN EXPONENT OF INDUSTRIAL BETTERMENT

SEE PAGE 94

CASSIER'S MAGAZINE

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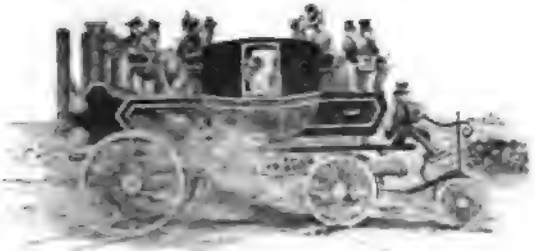
MOTOR OMNIBUSES FOR PUBLIC PASSENGER SERVICE

By Reg. G. L. Markham, M. Inst. M. E.



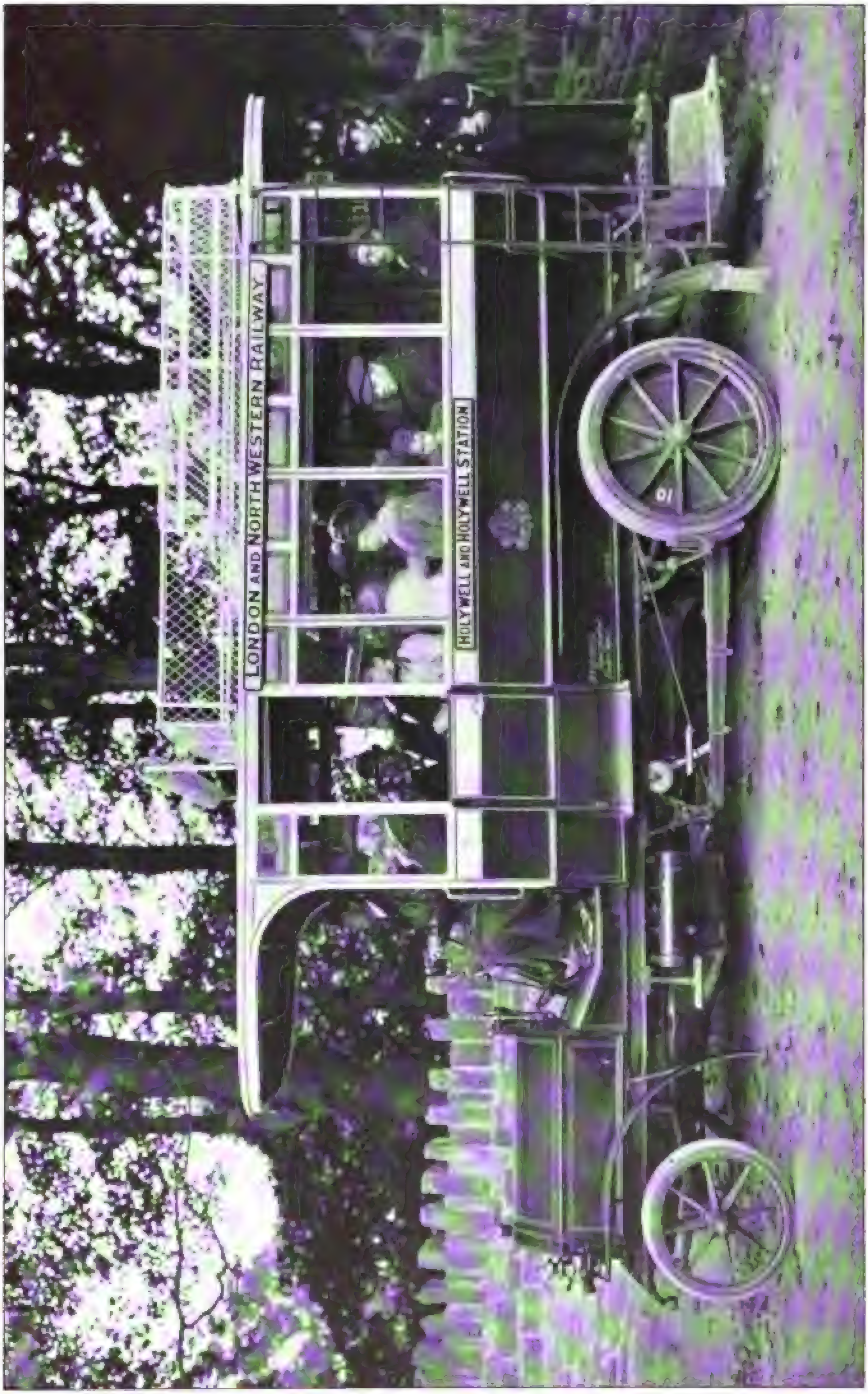
ONE OF GURNEY'S EARLY STEAM CARRIAGES, 1827

IN the automobile world the year 1905 will undoubtedly be remarkable for the great development in the use of the public passenger service motor vehicles. It has been one of those periods,—a feature in the process of all evolutions,—which punctuate the progress of the motor industry, and not ot the industry alone, but also, and perhaps this is more important, of the solution of the traffic problem which is yearly becoming more serious in great cities.

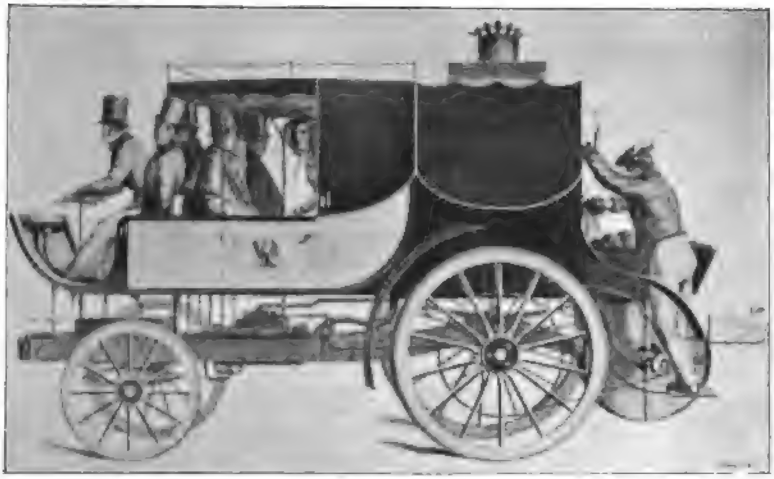
But while the past year has seen a boom in motor omnibuses (or is it merely the commencement of a boom?) the vehicles have been in use to a limited extent for several years with varying degrees of success, though with steadily progressive development.

The sage old Mother Shipton prophesied the introduction of horseless carriages about four centuries ago, and though it is difficult to say exactly when her prophesy was first fulfilled, there is no doubt that public service motor vehicles were in use in the first half of the nineteenth century, while Cugnot's steam carriage,—the first which is authentically recorded to have carried passengers,—was in evidence as long ago as 1769.

In the years from 1830 onwards several notable names occur in connection with motor passenger carriages,—steam coaches they were in those days,—and the measure of success achieved by these vehicles is really remarkable when all the circumstances are considered. Over seventy years ago a steam carriage was constructed by Summers & Ogle which attained a speed of 32 miles per hour, while one of Sir Goldworthy Gurney's coaches made a run of 84 miles in 10 hours, including stoppages. A service of Gurney's



A LONDON & NORTH WESTERN RAILWAY COMPANY OMNIBUS, BUILT BY THE MILNES DAIMLER CO., LTD., LONDON. PASSENGERS' LUGGAGE IS CARRIED ON TOP



MACERONI & SQUIRE'S STEAM CARRIAGE, 1833

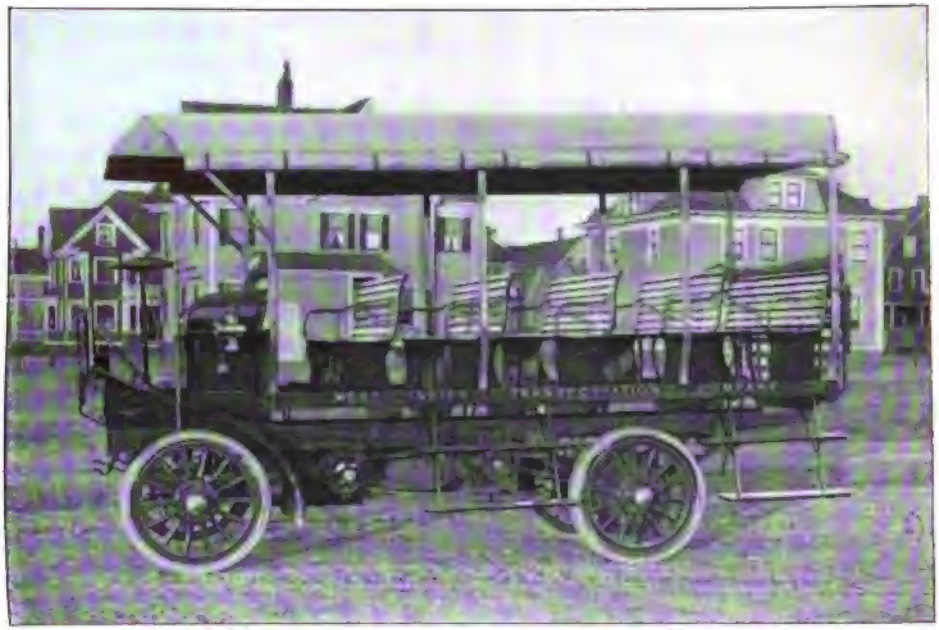
carriages was run by Sir Charles Dance for four months in 1861 between Gloucester and Cheltenham, during which time it was reckoned that the vehicles covered about 4000 miles and carried 3000 passengers.

Perhaps the most successful of the early steam omnibuses, and the ones most nearly approaching present notions of such vehicles in type as well as in nature of service, were those constructed by Hancock between 1830 and 1840. These vehicles were run constantly through the crowded streets of London, and performed regular journeys to and from the outskirts for considerable periods. The normal seating capacity varied from 10 to 22, though frequently persons were carried in excess of the accommodation provided. In 1833 one of the steam carriages by Maceroni & Squire made a nine-mile run to Harrow-on-the-Hill under the hour, including the ascent of the hill, which, it is said, was accomplished at the rate of 7 miles an hour without forcing the boiler.

About 1842, Hill, whose vehicles were among the most successful of the time, took one of his steam coaches to Hastings and back in a day,—a distance of 128 miles. Hill had considerable experience with his steam coaches, and he stated the results to show that passengers could be carried at double the speed and at half the expense of ordinary stage coaches.

It is curious that when treating of a modern revival in whatever domain, the average writer cannot resist the temptation to search out and serve up some of the earliest records by way of introduction, and I cannot claim to be an exception in this respect. But these few notes of the results achieved in the early days are here introduced deliberately, for, apart from the intrinsic value which they have as historical facts, they open out a field for speculation and inquiry which, when compared with present experience, is extremely interesting.

The motor industry in Great Britain practically dates from the Emancipation Act, as it was called, of 1896, and though manufacturers have built, and powerful, influential omnibus companies have experimented with, motor-buses during the last three or four years, yet it is not until after nine years of practical experience with motor road vehicles of all kinds that motor omnibuses have been evolved which satisfy the essential economic conditions. Then,



A GASOLINE OMNIBUS, BUILT FOR WEST INDIAN SERVICE BY THE KNOX AUTOMOBILE CO., SPRINGFIELD, MASS., U. S. A.

again, the perfected vehicle of to-day, though fitted with rubber tires, is not expected to exceed a maximum speed of, say, 15 miles an hour, while on a straightaway run a speed of 9 or 10 miles an hour would be considered a good average.

It would appear, then, that we are little, if any, more advanced now than were the early pioneers three-quarters of a century ago. The roads can scarcely have been kept in such good repair then as now; materials and knowledge of design were certainly inferior, whatever may be said of workmanship; and the cost of production, as well as running expenses, can hardly fail to have been considerably greater than at present. Yet we find these early lumbering old steam coaches travelling on occasion at speeds of over 20 miles an hour, making journeys of over 100 miles a day into the provinces, running for periods of several weeks continuously both in town and country, and finally we are told that tney could be run at half the expense of the stage coach!

How, then, are we to account for it? We cannot suppose that we are so much inferior to our grandfathers in mechanical design and construction as tnis comparison would imply. The question has frequently occurred to the writer during the last few years, and while he has not had the time to make the careful search into old records which might help to an answer, it seems to him that a solution may be found in that the statements we have do not include all the facts.

It must be remembered that for much of our information we are indebted to the manufacturers themselves of the respective vehicles, and while it is not contended that their statements are untrue, it is not to be expected that they would give publicity to all their troubles and failures. Other information of trial trips and long runs is extracted from the contemporary journals and newspa-

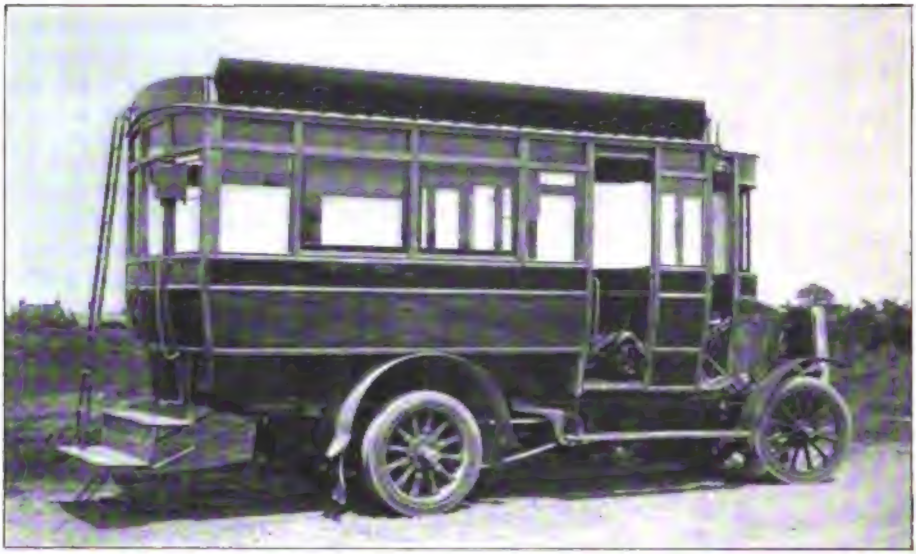
pers. We may be sure that their reporters went by invitation, had a good time, and would not be disposed to enlarge on the minor incidents of the runs, even if they observed them; that in the nature of the case they could not be experts even if they were mechanically-minded; and that they would record the vehicles and their own experiences as something absolutely novel, remarking only on the broad results. We may, therefore, not unreasonably suppose that the accounts we have are somewhat rose-coloured, while the facts we have not may be more sombre of hue.

We know that most of those steam coaches carried a mechanic and a stoker as well as a man to steer, yet we seldom hear of repairs or adjustments on the road. In the case of Gurney's vehicles on the Gloucester and Cheltenham service, however, we are told that there were sometimes delays owing to leaky boiler tubes; but to the recorder this seems of no moment at all, though he appears to have thought it remarkable that no accident happened to any person!

Then, again, we have fairly full accounts of the mechanical construction of these steam vehicles, and from our own experience we cannot believe that such machines could continuously be driven over rough and dusty roads without constantly needing attention. We are not told much about the wheels, but there are illustrations of the vehicles extant, several of them here reproduced, from which we can see that the type employed, as might be supposed would be the case, was the usual form of stage coach wheel with iron tires. In the present day the matter of wheels has been all along one of the greatest difficulties to the manufacturer of steam and other motor vehicles, and it is, therefore, impossible to believe that the early steam coaches, weighing, as they did, upwards of 4 tons, could run on ordinary roads without considerable trouble from that source.

A GERMAN ALCOHOL MOTOR OMNIBUS, BUILT BY THE MOTORFAHRZEUG UND MOTORENFABRIK, BERLIN

Finally, we learn that none of these vehicles remained in regular service for more than three or four months at the utmost, but we are seldom told why they were withdrawn.



ONE OF THREE STEAM OMNIBUSES, USING KEROSENE AS FUEL, BUILT BY MESSRS. CLARKSON, LTD., FOR A NORTH WALES BUS COMPANY. THESE VEHICLES AVERAGE ABOUT 80 MILES A DAY ON VERY HILLY ROADS

A DOUBLE DECK STEAM OMNIBUS BY THE SAME BUILDERS IN USE BY THE LONDON ROAD CAR COMPANY

Also, several companies were formed to run steam passenger vehicles, but they never seem to have made a profit, and in some cases they never managed to even place a service on the road.

If the inference be correct, we may take heart of grace that our modern efforts in the direction of motor passenger-service vehicles have hitherto been at least as successful as those of our grandfathers, while the promise of the present is to make all former successes appear as nothing. But those early results are none the less remarkable and interesting, for we must accept the facts and figures given for specific cases, even though we add our own commentaries on the general results.

In the old days the problem was to construct mechanical carriages which could run satisfactorily on common roads, and other points seem scarcely to have been considered. At the present day there are several questions of importance to be finally settled, but they are of quite another nature. There is no longer any doubt that mechanical public-service vehicles can run on common roads with reliability. It is now merely a question as to which is the most satisfactory type to adopt under the known circumstances.

The questions which at present have to be considered by prospective motor omnibus proprietors center in the one vital point of profit, while to the general public and to the public authorities, convenience, advantage, and safety are the matters of supreme importance. But all these points involve several others which are of minor moment only in proportion to the relation which they bear to the main issues dependent upon them, and they are the subject of constant discussion.

ONE OF THE OMNIBUSES OF THE LONDON ROAD CAR CO., LTD., BUILT BY MESSRS. SIDNEY STRAKER & SQUIRE, LTD., LONDON

With dividends ranging from 7 to 12½ per cent., paid by several motor omnibus companies, as has been the case for some time past, there can be little doubt that under proper management motor passenger vehicles generally can be made to yield a profit, whether they be run in large cities, in provincial towns, or in country districts.

Nevertheless, it must not be as-

A STEAM MOTOR OMNIBUS BUILT BY MESSRS. CLARKSON, LTD., CHELMSFORD, ENGLAND, FOR THE NORTH EASTERN RAILWAY. THIS IS ONE OF TWO OMNIBUSES USED BY THE NORTH EASTERN COMPANY IN THEIR OMNIBUS SERVICE BETWEEN BEVERLEY, BEEFORD AND DRIFFIELD

sumed that the motor-omnibus will prove remunerative under all conditions,—an erroneous assumption which has proved the undoing of many speculators before now and doubtless will again. Without at present going closely into details, it may be accepted as the result of experience that a single motor omnibus of the usual double-deck type (though the carrying capacity does not make a great deal of difference beyond a certain point) costs approximately 10 pence per mile to run, inclusive of all usual charges. Therefore, that sum has to be collected in fares per mile on the average before the question of loss is eliminated; and this figure assumes the vehicle to be in steadily continuous use. The bus might pay on even one or two journeys a day, being laid up during the slack time when the traffic did not warrant its running, but it is doubtful under these circumstances whether this sum would cover expenses; for though the expense of fuel, wear and tear of tires, etc., would not be incurred, standing charges, wages, and antiquation would still be going on.

The writer recently came across several similar cases where cheap public conveyances were badly needed, and where the probabilities of traffic at certain times of the day appeared to warrant the employment of motors. Motor-omnibuses were suggested, and in some cases even tried by enthusiasts who were beguiled by the running expenses shown and dividends declared by successful undertakings under very different conditions. Such ventures are almost certainly doomed to failure.

By the way, in one of those cases an urban district proposed to run a motor-omnibus as a council undertaking, and it is curious to note how keen such council and municipalities frequently are to embark on a doubt-

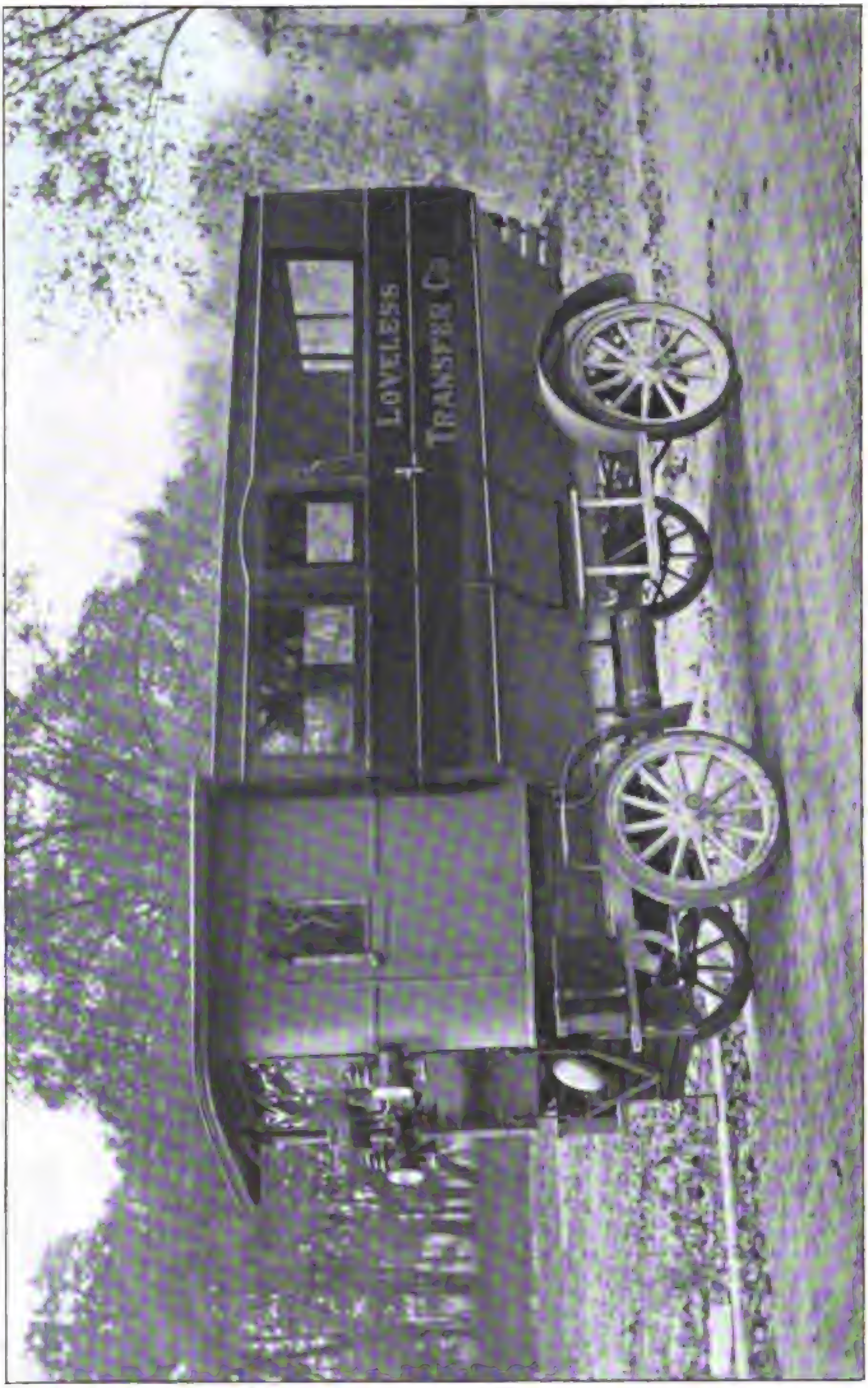
ful motor-omnibus or electric tramway venture when they would never dream of running horse conveyances, though they always employ horses for other municipal purposes. But motor-omnibuses can, and do, pay where the conditions are suitable. The fact that certain of the London companies recently reduced their fares which previously, for the horse buses, were not considered at all unreasonable, may be accepted as evidence of the earning capacity of the motor.

An analysis of the methods of the successful undertakings, however, will show that they are organized on proper lines. They have a considerable number of vehicles running upwards of 90 miles a day on routes where traffic is constant. They keep at least one motor-vehicle in six in reserve, ready to take the place of any that may have to come in for overhauling, and they keep plenty of spare parts and a staff of skilled mechanics always available at their depots.

This must not be taken as implying that the motors are unreliable or constantly giving trouble; it merely illustrates a wise precaution, for no piece of machinery can be expected to run continually on common roads under such severe conditions as does the modern motor-bus without requiring attention, and the old adage, "a stitch in time," etc., was never more applicable than in this case. It is not that the buses need frequent repairs, nor even repeated adjustments, but constant daily inspection and attention to small details insure that freedom from trouble which might otherwise occur unexpectedly and when least desired.

A PETROL OMNIBUS BUILT BY MESSRS. DURKOPP & CO., BIELEFELD, GERMANY, FOR THE NORTH EASTERN RAILWAY FOR THE SAME SERVICE AS THE ONE SHOWN OPPOSITE

A great deal depends on the driver of a motor-bus. On many of the London horse-buses a legend is displayed on the back of the roof seats urging passengers not to stop the



A GASOLINE MOTOR OMNIBUS MADE BY THE PACKARD MOTOR CAR COMPANY, DETROIT, MICHIGAN, U. S. A.

bus unnecessarily, for the sake of the horses. The Society for the Prevention of Cruelty to Animals is responsible for this notice, and it is a great pity that there is not a society for the prevention of cruelty to motors which might follow the same example, for the constant stopping and starting of the motor-bus is just as great a strain on the anatomy of the mechanism, to say nothing of the tires, as it is upon the constitution of a horse. But whereas the instinct of a horse teaches it how to apply its energy economically and to best advantage,—one might also credit the London bus-horse with reasoning facilities, for the driver interferes but little,—the driver of the motor-bus has a much greater and less elastic power under the control of a lever which he does not always apply with discretion.

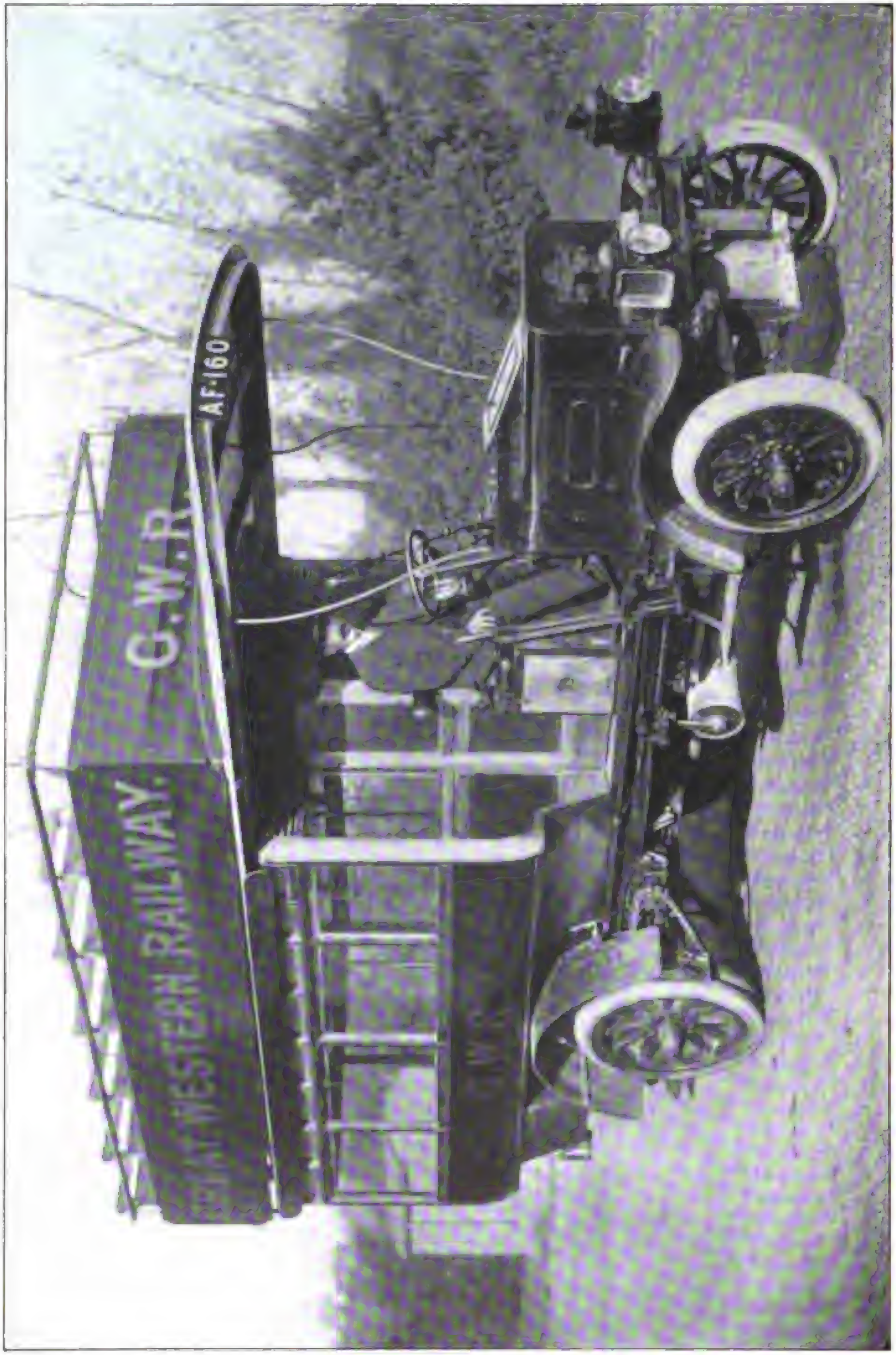
The brakes on a motor-bus are very powerful and quick in operation, and if they be applied suddenly, the wheels may be held, with the result that the rubber tires may be dragged along the road. Such action is, of course, very detrimental to the tires (never mind the roads!) and its frequent repetition will quickly ruin them, besides which the sudden application of the brakes is a fruitful cause of side slip. A good driver will stop his vehicle without injury to tires, and without racing his engine, and he will get away again quickly without letting his engine thump and thus unnecessarily strain the engine and gear.

There has lately been much discussion on the question of the respective advantages of motor-omnibuses and electric trams, and while there is something to be said on both sides, the advocates of tramway systems have frequently employed extravagant arguments in their anxiety lest their interests should be threatened. This, in itself, is surely a sign of the times, and another omen of much significance is the fact that several large and successful electric tramway corporations are themselves investing in motor-omnibuses.

The principal advantages which motor-omnibuses have over electric tramways, briefly stated, are that no permanent way is required, and no unsightly and sometimes dangerous overhead conductors or underground conduits are necessary; the vehicle is not confined to a single track nor even to any one route; the power required to maintain the service with motor-omnibuses is proportional to the number of vehicles running, so that in slack times some vehicles can be taken off without increasing the cost of running of the others; with electric trams the power required per car increases as the number of cars running is reduced. For the other side may be advanced the greater number of passengers which can be carried per vehicle; smoother running, sometimes; and greater economy in the production of power in large quantities.

This is not intended as an indictment of existing tramways in general, nor even of contemplated new undertakings, for in many cases where long distances are covered, and where the ordinary roads are generally rough, or where constant and heavy passenger traffic is experienced, electric trams can be operated at considerably less expense than motor-omnibuses; but still there are other points besides economy of running to be considered, and the successful application of the motor-omnibus should give pause to prospective promoters before finally deciding to embark on a tramway undertaking.

The great initial cost is one of the most serious matters to be considered in connection with electric tramways; and in the initial cost must be included the expenses of promoting measures for securing franchises, expenses of, possibly, the purchase, voluntary or compulsory, of property abutting on the route, of street widening, of laying the permanent way and the electrical conductors, whether they be on the con-



A GREAT WESTERN RAILWAY COMPANY MOTOR-BUS, MADE BY MESSRS. SIDNEY STRAKER & SQUIRE, LTD., LONDON

A PETROL MOTOR OMNIBUS BUILT BY THE MILNES-DAIMLER CO., LTD., LONDON, TO SERVE AS A FEEDER TO THE BATH ELECTRIC TRAMWAYS

duit, stud, or overhead system, of the erection and equipment of the power station, as well as the cost of the vehicles themselves. In arguing the case for the trams, I have seen, more than once, competent men, who must have known better, compare initial costs of the respective vehicles only.

Then, when the line is properly laid and equipped, other questions arise, such as immobility of route in the event of traffic being diverted temporarily or permanently for any reason, a failure of the current supply, causing a hopeless block of all cars on a section of the line, or the breakdown of another road vehicle across the tram line, all of which must result in loss of business. In the case of a motor-omnibus, a deflection of traffic can be followed, an unprofitable route can be abandoned, and a breakdown of a motor or of another vehicle does not disorganize the service.

So far as a comparison of horse-drawn and motor-driven omnibuses is concerned, the decided economic advantage of the latter is conclusively shown by the extensive way in which they are being taken up by the shrewd business corporations which have hitherto been content with horses. But from the public point of view they possess the great advantage of increased speed, due, not only to their own power, but also, in the hands of a good driver, to their ability to make the most of openings in crowded traffic, and so to push ahead where a slower vehicle would be unable to get through. In addition, there are the further advantages resulting from the use of motor-vehicles of all kinds,—a better sanitary condition of the streets, and less space occupied for a given load.

To how many has it ever occurred to compute the amount of room occupied by draught horses in the congested traffic of the streets of any of the large cities? A motor-vehicle,—omnibus, wagon, or cab,—is

A MILNES-DAIMLER OMNIBUS FOR THE LONDON GENERAL OMNIBUS COMPANY

rather longer than the corresponding horse-drawn vehicle, but considerably shorter than the vehicle plus the horse. Say that the motor-vehicle is two-thirds of the length of the corresponding horse equipage, and imagine motor-vehicles substituted for all others, and we have a third of the traffic cleared from the streets at once. Think what a relief that would be!

It is, perhaps, too much to expect such a desirable consummation in the present generation, but the advent of the motor-omnibus is a long stride in the right direction, and, as at the commencement of this article I said that the year that has gone was remarkable for the great development of the motor-omnibus, so the time will surely come when our descendants will refer to the next few years as the closing period of the draught-animal age. Would that we might see the fulfilment of this prophecy.

EXPLOITING AN INVENTION

By George Wetmore Colles

THERE is a theory current among the inventive fraternity that, however good patent laws may be theoretically, there is always some way in practice by which designing persons may succeed in appropriating the results of an invention without paying for them, or in getting possession of the patent and exploiting it for their advantage without giving any proper compensation for it, by availing themselves of legal technicalities.

That this does happen is a matter of common observation to those who come into frequent contact with inventors, but that it is the fault of the law is a proposition which cannot seriously be upheld. It is, on the contrary, in practically all cases, the fault of the inventor,—of his ignorance, his cupidity, his poor judgment, his lack of executive ability. The last three faults may be set down as incurable, but the fault of ignorance can be done away with by proper enlightenment, and I shall here endeavour to plant a few guide-posts which will help the reader to avoid some of those pitfalls into which others have fallen.

THE QUESTIONS AT ISSUE

To begin at the beginning is to begin before the patent is taken out. As the inventor, in ninety-nine cases out of a hundred, is unfamiliar with the patent law and its requirements, it will be necessary for him to employ an attorney. It is unfortunately the case that the profession of patent-soliciting carries a heavy burden of unworthies of the class termed among lawyers "shysters," varying from mere incompetents down to purely fraudulent concerns. This class is characterized in patent work by a pernicious activity which casts its reflection upon the legal profession at large. It is not part of my present object, however, to show how this class may be avoided; suffice it to say that the only way the inventor can start right is to choose a reputable solicitor.

If, for one reason or another,—frequently with the mistaken idea of saving a little money,—the inventor chooses a solicitor from the lower ranks, he has only himself to blame for the outcome, and has no right to rend the air with howls about legal injustice. Almost anybody acquainted with the forms of law can obtain a patent for him if his invention has any novelty or merit at all, but to obtain a patent which will "hold water" is a very different matter, and one requiring both brains and conscientious care, which are not to be had at the rate of so much a page nor can they be bought on any "no patent, no pay," scheme.

Nor do I intend to waste space in showing the patentee how, after acquiring his patent, he is to steer clear of the numerous sharks which follow the patent list of the official gazette, as their prototypes follow a ship at sea, to pick up what they can. As everyone who has ever taken out a patent knows, the issue of a patent is followed by an avalanche

of letters and circulars from these gentry, who have no other business but to get money out of inventors by hook or crook. The way to avoid being ensnared by these people is to let them severely alone.

Leaving aside the question of legal protection for his invention, on what plan can the patentee best lay out his campaign to put the invention on the market? The answer to this question cannot, in the nature of things, be the same in all cases. It will be widely different for different classes of invention, and will also depend very much upon the situation of the inventor himself, his talents and genius in the line of promotion, or executive ability, or financial management, or all three. Further, it will depend upon his general business environment, his business and social acquaintance and standing in the business world.

Just as a well-known author, or even an ephemeral celebrity of no literary talent whatever, can command a ready market for the product of his pen, while an unknown writer, even if talented, finds difficulty even in getting a hearing, so it is with inventors. The successful man of business, and more especially he whose position in itself gives him an opportunity to introduce his invention, say, in his own or allied departments, finds success an easy matter, while the inventor without such standing or environment may find his best efforts come to naught even for a highly meritorious device.

The exploitation of an invention may begin either with the first crude idea in the mind of the inventor or with the partially effected, but still imperfect, reduction to practice, or with the full-fledged exemplar ready for market. Again, the inventor's contract with others may begin before a patent has been applied for; or during the pendency of the application; or, finally, after the patent has been allowed or issued. At what stage it may best begin in each case will depend on the length of the inventor's own purse, and, to some extent, on opportune occasions which may hasten his action. Generally speaking, it is best for the inventor to keep the matter entirely, or as far as possible, in his own hands as long as he can.

THE EXPERIMENTAL STAGE

A mere idea is, in itself, not attractive to the investing public. Here and there you may find some semi-visionary who is willing to encourage it and put money into it, but this class is to be, generally speaking, avoided by the inventor even where his would-be assistant has a long purse, unless, of course, the money should be given freely without any demand for an accounting, as by some indulgent relative. In nearly all cases, however, it requires at least something tangible, some model, be it more or less practically operative, to demonstrate the invention, or convince the investor.

Nor is a mere model of itself very convincing, unless it can be shown to perform the actual work which the inventor claims for the invention in its commercial shape. Hence, in making any such model, or better, an exemplar, care should be taken that it does the work perfectly and without a hitch. Capitalists and investors generally are not mechanicians, nor are they especially concerned with the inward working and combination of parts of the machine; what they want is results, and the exemplification by actual eye-witness of one single practical result will do more to help the inventor than any quantity of theories, drawings, or supposed possibilities. Hence it is of the greatest importance to an inventor to bring his invention to a state of practical perfection before he attempts, for the first time, to interest capital.

In the case of a machine, the inventor should not content himself merely with a rude, home-made model, which can, by some urging, be put through its paces; but a regu-

lar exhibition model should be made, and for this purpose the services of a practical modelmaker should be secured. Such models are often costly, yet they are not only indispensable, but frequently prove to be worth their cost several times over in assisting the inventor to perfect his invention. I may call attention here to one point which illustrates the great practical sagacity which has been shown by the judicial department of the American Government in evolving its present system of patent law from the written statutes, namely, that no invention, even the simplest, has been actually made until it has been reduced to practice. And it is just this point that I wish to emphasize here,—that, however skillful an inventor may be as a draughtsman, designer, or engineer, it is impossible to perceive with certainty all the contingencies which may arise to render his invention a partial or complete failure.

It may be found, for instance, that while the parts worked together quite in the manner contemplated by the drawings, there is some vital point which has been forgotten; some practical objection which must be overcome, rendering the product imperfect; or again, the parts may interfere with one another, and fail to perform a complete cycle for this reason, or it may be (and frequently is) found that while the machine performs the cycle perfectly in nine cases out of ten, the tenth time some trifling item of back-lash or lost motion will cause it to turn out an imperfect article, or even to cause breakage of the machine itself. And such apparently trivial difficulties often have for their result the entire reorganization of the machine; the whole work must be begun anew on a different basis, or else complicated interlocking or like mechanism must be added which may change the entire commercial situation, either by making the machine practically perfect, or, on the other hand, by making it so expensive that it cannot compete with others on a commercial basis.

In the case of such things as tools, novelties and the like, which have no moving parts,—those which are to be described as articles of general use rather than producing mechanisms,—there are two principal questions to be answered. The first is, at what cost can they be produced and sold? The second is, will they take with the public? The answers to these questions will form the "raison d'être" of the invention. Many hundreds, perhaps thousands, of inventions are annually patented which are failures from the start for reasons indicated by one of these two questions.

Both of these questions ought to be decided positively before any money is put into the invention, at least any more than is necessary to protect it temporarily, as by filing the patent application. Several of the articles should be made up in finished form and shown to different classes of users with a request for their opinion. For instance, a new style of wrench should be taken, or sent, to some large hardware dealers (not manufacturers) with a request for their opinion as to whether they could sell the article and at what price, in wholesale lots. A few samples also might be distributed among practical machinists with requests for their opinions after a few weeks' use.

Then, if the reports be favourable, the price should be figured out at which they could be produced on a regular manufacturing scale, all labour and material, expenses of management, etc., included. In this calculation it is best to take it on the basis of contracting the work out, and application for estimates for furnishing the article should be made to firms equipped for manufacturing of this kind on contract.

If the estimate of cost thus obtained exceeds that which it is ascertained can be got from the wholesale jobbers, then either the inven-

tion must be abandoned, or it must be so altered in construction that it can be made at a sufficiently lower price to enable it to be sold at a profit. In the majority of cases, I find that this simple matter of addition and subtraction, with a small ingredient of exertion, has not been gone through with at all, and the inventor merely goes upon theory, rather than upon facts which he could easily ascertain in advance.

In nearly all cases, too, inventions of this class, as first evolved, while they may be perfectly adapted to their functions, are too expensive to produce, and their profitable working becomes a matter of what theorists style "mere detail," but what, instead of being "mere" anything, constitutes the real crux of the whole matter. Those not engaged in practical manufacture little realize how great and important an item is this saving in the cost of but trifling matters of construction. The reason of this is that the intense competition of the open market leaves at best but a narrow margin for profit with most articles, and the large profits are made by the use of cheap processes of production and the enormous multiplication of the articles so sold.

To illustrate my point more practically, let us say we are to manufacture a new style of egg-beater. Such and such parts must be castings, which will weigh so much and cost so much, and they must be so designed as to be free from projections and like parts which would make drawing from the mould difficult and breakage easy. Malleableizing may thus be made unnecessary. Clever designing may make it possible to avoid right-and-left patterns and to use the same part for both sides, thus dispensing with one shape. Sheet-iron stampings should be made (if possible) by one operation and one pair of dies. Brass and other expensive metals should be avoided where possible, as should also machine work of every description.

It should be remembered, too, that the drilling and tapping of holes and the use of bolts and nuts are the cheapest class of machine work, and should be substituted for other kinds wherever possible. Many complicated machines are now made which require the drilling of hundreds of holes for each machine, but which have not a single planed or turned surface in them. It should also be remembered that wire constructions can usually be made much more cheaply than those of sheet-iron strips or cast metal, and have often great advantages in use. And so on indefinitely. To this end, the greater the ingenuity employed in devising mechanical expedients, the greater will be the success, and the greater the profits in the finished article. It is often a matter of a fraction of a penny which decides the question whether the article will be a commercial success or a failure.

All these things should be carefully worked out by the inventor himself in advance of any negotiation for capital, so that he comes full-armed at every point with facts and figures, not only for defence, but also for attack, to carry conviction to the person to whom he speaks, and leave no room for doubts and second thought. It should so convince him that not only is he satisfied himself, but that he can in like manner convince others, or at least not be talked over into a feeling of uncertainty by their objections. Also, it seems scarcely necessary to remark to persons gifted with reasonable foresight and common sense, that the worst possible thing to do is to misrepresent the actual facts or figures. If the inventor cannot convince himself that his invention will be a success, he had better abandon it entirely rather than try to convince others.

In the case of a chemical process or a composition, there should be a like experimental season before it is attempted to interest any capital, and the inventor must be prepared to

make an actual demonstration, in the one case by going through the process itself, and in the other by an exhibition of the application of the composition, or by a properly verified showing or a technical report of tests to prove what has been accomplished by it.

Unfortunately, there are few inventors who are sufficiently patient or pertinacious to pass their invention through such a long and difficult experimental stage as I have above outlined. But I have advised this course with full realization of the loss of time and the expense which is occasioned thereby, and with the conviction that it is for all ordinary inventions the very wisest course to be pursued. I believe I am safe in saying that few or no inventors who have followed it conscientiously have been sorry for it afterward, or have failed of success in securing capital when they have once undertaken to do so.

Of course, there are some inventions with which experiment, at least on a very extended scale, is impossible. For example, the inventor of a new form of suspension bridge could not be expected to build bridges by way of experiment, and a model would conceivably not demonstrate his point. He could, however, perhaps induce the builder of a bridge to adopt it experimentally without pay, on the understanding that no rights as to the patent were forfeited beyond that instance; or he could, if necessary, give such a builder a limited license under the patent or patents. The inventor of a new type of locomotive boiler or a novel method of building construction would, in like manner, find it necessary to induce locomotive builders or building contractors to try his devices experimentally on a similar basis.

During this experimental stage the question of patent rights for the invention must not be left wholly out of consideration. And here let me disabuse the novice of any idea that he may have as to the cost of securing a patent being his only or even principal expense in the matter. The procuring of a patent is only the beginning of the inventor's troubles, and the cost of it is frequently, if not usually, an inconsiderable item compared with the ultimate expense to which he is put.

The question as to when the invention is sufficiently complete to warrant the application for a patent is one which will depend largely on the nature of the invention, the necessity of making it public, and the length of time which the experimental stage will probably occupy; but before filing any application, or proceeding very far with his experiments, a search should be made to discover the previous state of the art. This is best done through a patent attorney, to whom the invention is first submitted, and a reputable patent attorney (that is, one of the class heretofore referred to as such) can be depended on to keep the invention secret. Such a search costs but $5 or $10, as a rule, and no money could be better spent. The writer advises in many cases the procuring of all the patents in the special sub-class of invention, and this can be frequently done at a cost approximately equal to or but little exceeding the cost of the search.

The result of such an examination will usually be a surprise to the inventor, unless the invention is very technical, and the inventor an expert in this particular line. While he may not find anything exactly the same as his invention, he will often find things very similar to it, and embodying the same principles more or less perfectly, and these may be discovered in old patents dating back thirty to fifty years.

The searcher marvels that a thing so obviously good could be known to the public and yet not be in use, but he sees it to be a fact. The reason may lie in the practical imperfection of the former patent, and the practical perfecting of the old idea may enable the new inventor to ob-

tain a new patent which will still be valuable, though, of course, it cannot be basic, and it will be more vulnerable to imitation than if there were no such anticipation. Again, the former invention may have been, as is the case with so many inventions; born before its time, and no one cared to exploit it since the patent expired; or again, the original inventor may have tested it and found it wanting.

In either case, should the anticipating patent disclose substantially the same thing as that for which the search was made, the later inventor must either drop it entirely or substantially improve it to such an extent that the advance in the art will be clear and unmistakable; for let him be sure that this old patent will be turned up in the Patent Office as soon as his application is made, and will not escape the notice of the intending investor who submits it to the usual preliminary examination.

Supposing the test of novelty to be successfully met, the inventor is allowed by the laws a reasonable time for experimental use, and again a period of public use in which to apply for a patent; but it is generally not advisable to let it run so far. Not only is publicity likely to lead to the appropriation of the invention by others, but it may be independently invented by some one else working along the same lines.

It is, therefore, dangerous to postpone the patent application for many months, as the inventor constantly runs the risk of losing the fruits of his labour and genius. Every year there are several hundreds of contests or interferences, as they are called, between rival inventors, and while the law requires the patent to be issued to the first inventor, its practical construction gives the overwhelming preponderance of advantage in most cases to the first to apply for a patent. The patent once applied for, the inventor may feel fairly safe against later comers, providing he does not allow it to become abandoned.

As regards foreign patents, the stipulations of the International Union, of which nearly all the most important countries of the world (the principal exceptions being Austria, Australia, and Canada) are now members, allow the inventor the benefit of the date of application in his own country for patent applications in the other countries of the union, provided the foreign applications be in each case filed not more than one year later. The inventor thus has this time in which to experiment freely and publicly without any danger of appropriation abroad.

I repeat that the fact should be borne constantly in mind that an invention, however clever, cannot be exploited without expense, and the expense and difficulty of securing a patent are in most cases trivial compared with the expense of actually perfecting the invention and putting it on the market. There need never be any question in the inventor's mind as to the possibility of getting the novel and meritorious features protected by a patent after the question of novelty is once settled, any more than there need be that the issue of a patent does not mark the successful issue of the invention.

To be Concluded in the June Number

THE ELECTROCHEMICAL AND ELECTROMETALLURGICAL INDUSTRIES IN 1906

By John B. C. Kershaw, F. I. C.

TWENTY years ago industrial electrochemistry was represented by only one manufacture,—that of refined copper. To-day over twenty industries are found in which electricity is employed as the agent of chemical change, and the list of products of the electrolytic cell or of the electric furnace is still growing.

It is true that the expectations of the earlier inventors and promoters of electric processes have not been altogether realized. The old Le Blanc alkali process still survives and competes successfully with the newer electrolytic alkali processes, and the calcium carbide industry has not attained the huge proportions upon which company promoters based their hopes and estimates of profits in the years 1896 to 1898. But notwithstanding disappointments and losses in particular branches, the electrochemical and electrometallurgical industries are undoubtedly advancing. Each year sees the growth and development of certain of the older manufactures, and the addition of new ones to the list of industries. The electrolytic copper refining industry has attained a magnitude and an importance undreamed of by James Elkington, who inaugurated it at Pembrey, in South Wales, nearly forty years ago. The aluminium and alkali and bleach industries, though stationary, are in a healthy condition, and a great increase in the production of the former is expected in the near future.

As regards new developments, the application of the electric furnace in metallurgy has led to the production, upon a commercial scale, of alloys of iron and the rare metals, and consequently to the cheapening of many special brands of steel. The attempts now being made to apply the same agency in the production of iron and steel are being followed with intense interest, and, if successful as commercial ventures, these methods may lead to most important developments and changes in the iron and steel industries of the world. The fixation of atmospheric nitrogen and the artificial production of nitrates point to another direction in which electricity may have a great future when the natural beds of sodium nitrate in Chili and elsewhere have been exhausted. Details of the present position in these and other industries will be found below.

ALKALI AND BLEACHING POWDER

The electrolytic alkali and bleach industry is represented in Great Britain by two companies,—the Castner-Keller Alkali Company and the Electrolytic Alkali Company, which operate the Castner and Hargreaves-Bird cells and processes, respectively. The former has works at Weston Point, and there 4000 H. P. are developed by gas-producers and gas engines, and are utilized in the manufacture of metallic sodium, caustic soda, bleaching powder, zinc chloride, sodium peroxide and cyanide and other products. The Hargreaves-Bird process is worked at Middlewich, in Cheshire, with a plant utilizing between 1000 and 2000 H. P.

In France and Germany there are a number of electrolytic alkali works, using either the German "Elektron"

GENERAL VIEW OF THE CHLORATE WORKS AT CHEDDE, FRANCE

process, or the Castner mercury-cell process. The chief centres of the industry in Germany are at Bitterfeld and Rheinfelden. In France, electrolytic alkali works are located at La Motte and at Moutiers; in Switzerland, at Chebres; in Belgium, at Jemeppe; in Austria, at Aussig and Jaice; whilst Russia, Italy and Spain also have factories engaged in this industry.

No figures of any value can be given, however, for the power utilized in the manufacture of alkalies and bleach in these works, for many of them manufacture other products than alkali and bleaching powder. A larger proportion of the chlorine of the salt used as raw material of the process is obtained by the electrolytic process than by the old Le Blanc process, and the extension of the electrolytic alkali processes in Europe has been followed by an excessive production of bleaching powder. Attempts are now being made to employ the chlorine from the electrolytic cells for other purposes, as, for instance, in the manufacture of pure hydrochloric acid, carbon tetrachloride, and stannic chloride.

In America, the electrolytic alkali industry has also undergone considerable development, the largest installation of plant being at Niagara Falls, where the Castner cell is using between 6000 and 7000 H. P. in this manufacture. The Acker Process Company are also producing alkali and bleaching powder at the same place, by a cell in which fused sodium chloride is employed as electrolyte, in place of an aqueous solution. There are, in adition, in America several works using diaphragm cells, for the production of sodium hydrate solutions by electrolysis.

The total number of electrolytic alkali works in operation in Europe and America is now between twenty

and thirty, and the power employed in these works lies between 30,000 and 40,000 H. P. The electrolytic alkali industry at the present time, owing to the over-production of bleaching powder and other chlorine products, is not extending, and as the old Le Blanc works and the ammonia soda works are quite holding their own, the future of this industry is somewhat uncertain.

ALUMINIUM

The manufacture of aluminium by the electrolytic method was commenced in America by Hall, at New Kensington, in 1888, and in 1889 a practically identical process was in use at Neuhausen, in Switzerland, the details having been independently worked out by Heroult and Kiliani. Since the latter year the production of aluminium has increased enormously, and at the present time the annual output of the metal is estimated to be 8000 tons, as compared with 85 tons in 1889. The price has fallen in the same period from 10s 6d per pound to 1s 3d per pound, and if a cheaper raw material than refined alumina could be used in the electrolytic baths, a still further reduction in price would be possible.

Nine works are now operating either the Hall or the Heroult methods of aluminium production, and between 40,000 and 50,000 H. P. are employed in the industry. The nine works are situated as follows:—America, 3; France, 2; United Kingdom, 1; Germany, 1; Switzerland, 1; Austria, 1. A works is now in course of erection in the valley of Pescara, in Italy.

The British Aluminium Company, with works at Foyers, in Scotland, and the Neuhausen Aluminium Company, which controls the production in Germany, Switzerland, and Austria, are taking steps to increase their output, and in the near future a considerable increase is expected in the aggregate output of the metal, which has been stationary at about 8000 tons since 1902. The demand for the metal is growing in connection with motor-car and railway carriage work, the latest example of this use of the light metal being for the inside of the cars for one of the London underground tube lines.

Very large amounts of the cheaper brands of aluminium are now being employed in the casting of iron and steel. The Goldschmidt "Thermit" process for welding tramway rails, and for repairs of castings, etc., is a new use, responsible for the annual consumption of many tons of aluminium in the form of powder.

The problem for those engaged in the aluminium industry is that of cheapening the production, and many patents are being taken out both in Europe and America having as their object the direct production of aluminium from bauxite, or the refining of impure aluminium by a process similar to that used in the copper industry. When this problem is solved, and the necessity for using the comparatively costly refined alumina in the electrolytic baths is done away with, the metal aluminium will once again undergo a great reduction in price and its field of usefulness will be considerably widened.

CALCIUM CARBIDE

The calcium carbide industry, after many vicissitudes, has attained a position of some stability, and though acetylene gas has not displaced other illuminants in the way that was at one time expected, it is being used to a much larger extent than is realized in some quarters as a substitute for oil. According to the most recent estimates, there are now sixty-eight works engaged in the production of calcium carbide, and the aggregate production amounts to about 90,000 tons yearly. The United States, Italy, and France are the largest producers, and also head the list of consumers. The consumption lies between 80,000 and 90,000 tons per annum, and is steadily growing.

Central acetylene gas generating

THE CHEDDE CHLORATE WORKS. THE ENTRANCE TO THE WATER POWER TUNNEL

installations are springing up all over Europe and America, in districts where neither coal gas nor electricity supply exists. The price of calcium carbide has now fallen to $70 per ton in America and to £14 also in Great Britain. It seems probable that there will not be any great variation from this figure in the future, since it is unlikely that any marked improvements in the process of manufacture as now carried out can be made, and the cost of the raw materials, lime and coke, and of the electric power used for heating the furnaces is now well known. In spite of the early losses, due chiefly to financial speculation and unwise company promotion, the industry may be regarded as a healthy one.

CARBORUNDUM

Carborundum is a carbide of silicon, and was first produced in quantity by E. G. Acheson, at Niagara Falls, by heating coke, sand, and sawdust to a temperature of nearly 4000 degrees C. in an electric furnace.

The manufacture has grown into one of considerable importance, owing to the excellent abrasive properties of the product, and is entirely controlled by the Carborundum Company, at Niagara Falls, who own all the patent rights of the process. The output of carborundum has grown from 1000 pounds in 1892 to 7,060,000 pounds in 1904, and the price has fallen to 9 cents per pound; 1500 KW. are now utilized at the Niagara

THE TAIL RACE OF THE CHEDDE WORKS

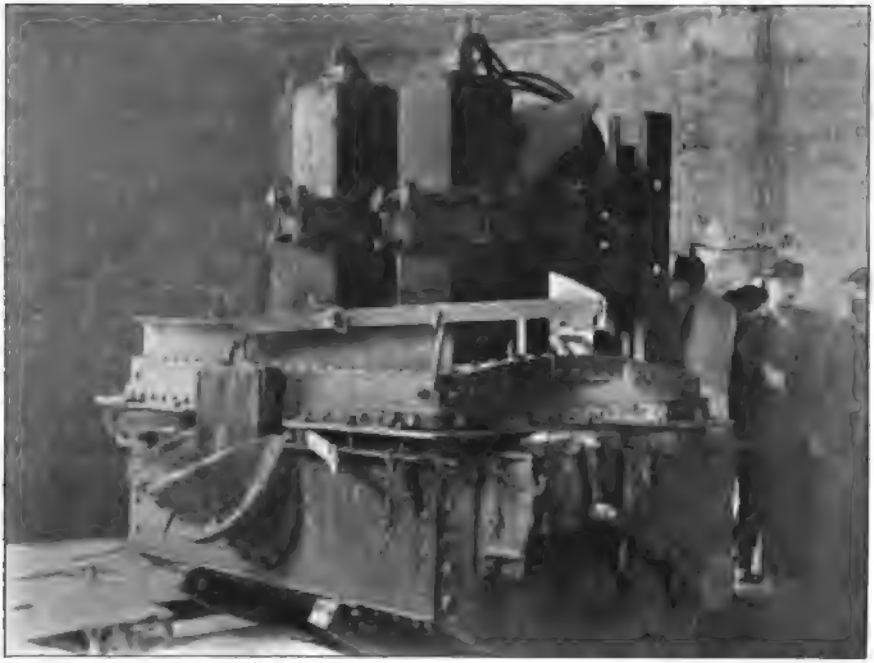
Falls factory. The material is graded into several sizes, and is sold as a substitute for emery in the form of grinding-wheels, tools, paper, and other products. The industry is a growing one.

CHLORATES

Chlorates of potash and soda are made by the electrolytic process at seven works, five of these being in Europe and two in America. The largest of these works is that of Corbin & Cie, at Chedde, Savoie, France. Here 13,000 H. P. have been developed, and 4000 tons of chlorates, in addition to other products, are produced annually. Between 30,000 and 40,000 H. P. are available in the works where this manufacture is at present carried on, but the price of chlorates since the advent of the electrolytic process has fallen to a very low figure, and the industry is not now a very profitable one. The tendency in the works is, therefore, to apply the available power to more money-making manufactures, and to reduce the proportion utilized for chlorates. The industry, although stationary, may be regarded as a healthy one; but no expansion can be looked for until the price of chlorates improves. The romantic position of the electrolytic chlorate works at Chedde, almost under the shadow of Mt. Blanc, is illustrated in the several views on this page and on pages 24 and 26.

COPPER

The history of the electrolytic copper refining industry provides the most striking example of growth and



A HEROULT ELECTRIC STEEL FURNACE

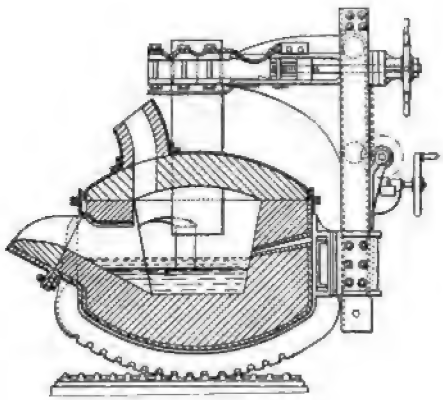
development which the electrochemical and electrometallurgical industries afford. Started, in 1869, on a very small scale at Pembrey, in South Wales, by James Elkington, head of the famous Birmingham electroplating firm, the industry has expanded until the annual production of electrolytic copper has reached the enormous total of 350,000 tons. Over 60 per cent. of tne raw copper produced is subjected to the electrolytic refining process. This expansion is due to two causes,—first, to the demand for a very pure copper for electrical engineering construction purposes; and second, to the presence of silver and gold in nearly all copper ore mined in America. The industry has, in fact, developed chiefly in America, and over 86.5 per cent. of the total output of electrolytic refined copper is now taking place from American refineries.

In the early days of the industry the output at Pembrey was about 250 tons per annum. The largest of the American refineries now produce 350 tons per day, equal to 120,000 tons per annum. Thirtv-two refineries are now in operation; nine of them are located in America, nine in Germany, six in the United Kingdom, four in France, two in Russia, and two in Austria-Hungary.

The output of the American refineries is stated to have doubled within the last six years, and the capacity of the nine American electrolytic plants is now nearly equal to the annual production of raw copper in that country. The plants of the American Smelting & Refining Company, of the Lamar Company, of the Nichols Chemical Company, and of the Raritan Copper Company have all been enlarged recently, and the annual output of these four works alone will shortly equal 300,000 tons of refined copper. The American electrolytic copper refining industry is, therefore, in a wonderfully expansive condition and is growing almost too rapidly for its continued health and prosperity. In Europe, on the other hand, the industry is stationary, or actually declining, as a result of the progress on the other side of the Atlantic, for the American copper is that which pays best for the electrolytic refining operations.

HYPOCHLORITES

The electrolysis of solutions of common salt yields caustic soda, sodium hypochlorite, or sodium chlorate in solution, according to the manner in which the electrolytic



VERTICAL SECTION OF THE HEROULT ELECTRIC STEEL FURNACE

cell is worked. The making of the second of these products,—hypochlorite solution by electrolysis for bleaching and disinfecting purposes,—has become an established industry, and a large number of cells has been patented for carrying on this manufacture.

It is impossible, however, to give any reliable estimate of the number of installations, or of the power utilized in these cells for hypochlorite production. The largest installation is probably at Lancy, in France, where Messrs. Corbin & Cie have a large cellulose factory utilizing 700 H. P. in the cell room. In America there are also similar factories where an electrolytic process is used for bleaching the wood-pulp, and in Great Britain interest has been recently aroused by the

proposal of the Poplar Council to install an electrolytic plant for the production of the hypochlorite solution required for disinfecting purposes.

ELECTRIC IRON AND STEEL MAKING

The serious attempts to apply the electric furnace in the iron and steel industries date only from 1899. These methods have already attracted great attention from metallurgists in all countries, and at the present time considerable development is occurring in connection with them in France, Germany, Scandinavia, and also in the United States and Canada.

The methods for producing steel in the electric furnace are based either on arc or resistance heating, and have been due chiefly to the experimental work of French electrometallurgists. Heroult, who shares with Hall the honour of the discovery of the electrolytic method of producing aluminium, has been one of the leading pioneers in this new industry.

The Heroult furnace process has been operated at La Praz, in France, and at Kortfors, in Sweden, since 1900, and over 5000 tons of steel have been produced with it. Arrangements have recently been completed for the introduction of the Heroult steel refining process on a large scale into Germany and the United States (at Remscheid and at Syracuse, respectively), and M. Heroult himself is now at Sault Ste. Marie, in Canada, engaged upon experimental work with an electric furnace method for reducing Canadian iron ore.

The Keller furnace and process are working in France at Livet and at Kerrousse, while Gin, another French electrometallurgist, has designed a furnace for steel production which is undergoing trial at Plettenburg, in Germany.

In Sweden the Kjellin furnace and process have been operated at Gysinge, near Stockholm, since 1901, with furnaces of increasing size. Several thousand tons of steel of high quality have been produced there. This method of steel production is about to be introduced into Switzerland. The Kjellin method differs from the other electric steel processes in that induced current is employed to heat the material in the furnace, and an exceptionally pure iron is produced.

In Italy the Stessano furnace and process are about to undergo industrial development near Turin, and trials with one of the new processes are also being carried out in Spain. It is yet too early to say how far these various processes and methods of steel and iron production will meet with permanent success, but that one or more of them are destined to survive the present testing period seems certain. The Heroult furnace at present is making most headway, and given cheap electric power and expert management, it would appear to be settled that this furnace and process can be worked at a profit. At present scrap iron and steel are employed as the raw material for most of these electric furnace methods of steel refining.

If the electric furnace, however, becomes a general feature in the iron and steel metallurgy of the future, molten pig-iron from the blast furnaces will probably form the raw material, and the electric current required for heating the furnaces will be generated by the waste gases of the blast furnaces, in large gas engine plants. In this way both the heat of the molten pig-iron and the power stored up as thermal energy in the blast furnace gases will be saved and utilized, instead of wasted.

SPECIAL ALLOYS OF IRON

The production of ferro-chrome, ferro-silicon, and other alloys of iron with manganese, tungsten, and vanadium in the electric furnace has developed into an industry of magnitude and importance since the value of these alloys in the manufacture of special steels has been demon-

strated and explained. In Europe, Keller, Leleux & Cie, at Kerrouse and Livet; the Société Electrometallurgique Francaise, at Le Praz and at St. Michel, and the Girod Company, at Ugine and Courtepin, are the chief producers of these alloys by electric furnace methods. Messrs. Goldschmidt & Cie use the aluminium reduction process for producing the same alloys free from carbon at Essen, in Germany. Messrs. Keller & Cie are reported to be producing 250 tons of ferro-silicon and 80 tons of ferro-chrome per month, while at Courtepin the Girod Company are producing large amounts of ferro-tungsten.

In America the industry is less developed, and the ferro-silicon used in American steel works is imported, to a considerable extent, from Europe. The explanation of this is that electric power, which represents the chief item of cost in the production of these alloys, has been more cheaply developed in France and Switzerland than at Niagara Falls. The Wilson and Cowles Companies, however, produce ferro-chrome and other alloys in America, and Mr. Auguste J. Rossi, at Niagara Falls, has been engaged in the development of new methods of producing ferro-titanium from titaniferous iron ores.

LEAD

The attempts made in the past to apply electric methods to the extraction or refining of lead have not been very successful, and more than one process, after attaining trial upon an industrial scale, has ended in loss for its inventor and financial supporters. The works of the Electrical Lead Reduction Company, at Niagara Falls, where the Salom method of reducing lead sulphide to spongy lead was operated for some years, are, the writer believes, now shut down, and the Betts refining process, in use at Trail, British Columbia, is the only example of electrical process used in the lead industries.

The Betts process depends upon the use of lead fluorsilicate as electrolyte, with lead bullion or raw lead as anode material. The plant at Trail was enlarged during 1905, and now comprises 82 vats, though only 28 of these are kept in regular use. Each vat is 7 feet long by 30 inches wide, and contains, when fully charged, 20 anodes and 21 cathodes. The capacity of the plant is about 20 tons of refined lead per day. The separation of the lead from the copper, bismuth, and cadmium contained in the raw lead as impurities is reported to be almost perfect. A similar plant is now being erected at Newcastle, England, for Messrs. Locke-Blackett & Co.

NICKEL

Electrolytic methods in the nickel industry have not made progress, chiefly because of the fact that there is no demand for the very pure nickel obtained by the electrolytic refining process, and that the ordinary metallurgical methods of reducing and refining the metal now yield a product of high purity,—99.2 per cent. In America for many years the chief nickel producing company has made use of an electrolytic refining process, but this has been discarded, and all the nickel produced in America is refined by ordinary metallurgical methods.

In Germany, a nickel extraction process, known as the Hoepfner process, is in use, a plant with a capacity of 16 cwts. nickel per day having been operated by the Allgemeine Elektrometallurgische Gesellschaft, at Papenburg, for many years past. This process depends upon the production of mixed solutions of copper, calcium, and nickel chlorides by bleaching the ore, and the final separation of the copper and nickel from these solutions by electrolysis. The Hoepfner process, as worked at Papenburg, is not very successful, and the writer is unaware of the existence of any other installation of plant for working it upon a commercial scale. Direct electric smelting methods have been attempted

THE NITRATE FACTORY AT NOTODDEN, NORWAY

with copper and nickel sulphide ores, but so far without achieving any marked success.

NITROGEN COMPOUNDS

Nitrogen in its combined forms, whether as ammonia or nitrate, is one of the most valuable of the elements found upon the earth, for, upon an adequate supply of nitrogen compounds to the soil depends success in raising the crops of corn and other cereals which sustain animal life. Up to the present time the immense beds of sodium nitrate found in South America have been the chief source of the extra nitrogen required to supply the annual deficiency of natural manures in corn-growing countries. This source of supply, however, is being depleted rapidly, and it is, therefore, with great satisfaction that electro-chemists have hailed a method by which the immense reservoir of nitrogen in the atmosphere can be tapped and made to contribute to the support of animal life on this planet.

It has long been known that when an electric spark discharge passed through air, the nitrogen and oxygen combined and formed nitrous oxides. The attempts to apply this method upon an industrial scale, however, were not successful until quite recently. The amount of nitrous oxides formed per cubic foot of air by spark discharges is necessarily small, and the condensation of these oxides and the formation of nitrates from them were matters of some difficulty. To obtain successful results, a very large volume of air also must be submitted to the discharge per minute.

The means for obtaining a high yield devised by Lovejoy and Bradley, two American inventors, was to have within the apparatus an immense number of spark discharges, each of short duration. This method was worked upon a commercial scale by the Atmospheric Products Company, at Niagara Falls, for some months in 1902 and 1904, but failed to achieve financial success. Other chemists who have devoted their time and energies to the subject also failed. Two Norwegian chemists, Messrs. Birkeland and Eyde, have, however, apparently solved the problem, for their method has been oper-

ated upon a continually increasing scale of operations at Notodden, in Norway, since May, 1905, and independent experts have reported favourably on the results obtained. The plant now installed consists of three dynamos developing 700 H. P., and the daily production equals 30 cwts. of nitric acid. The air is drawn through the apparatus at the rate of 75,000 litres per minute.

The asorbing towers are fed with water and milk of lime, and remove 95 per cent. of the nitrous oxides. A company is being formed in Christiania to exploit this process. The factory at Notodden is to be purchased by the new company, and is to be enlarged, a total power development of 30,000 H. P. being contemplated. The annual output of calcium nitrate, when the factory is completed, will, it is estimated, be about 20,000 tons.

Another method of fixing the nitrogen of the air is to form calcium cyanide, by passing air over heated calcium carbide. This compound can be directly applied to the soil as a fertilizer, and is reported in Germany to be 25 per cent. less efficient than sodium nitrate. Independent trials in Great Britain have not been so satisfactory, but calcium cyanide is being manufactured on an industrial scale both in Germany and Italy, and is being sold to farmers and others as a fertilizer, under the name of "Kalkstickstoff." No figures are available for the output of this compound.

THE GENERATING PLANT AT THE NOTODDEN NITRATE FACTORY

OXYGEN AND HYDROGEN

The production of oxygen and hydrogen gas by the electrolysis of water had developed into one of the minor electrochemical industries in France and Germany prior to 1905. Several types of electrolyzing cell were in use, the majority employing a dilute solution of caustic soda as electrolyte. Schoop, however, made use of a dilute sulphuric acid solution in his cell. The gases were employed chiefly for heating purposes in special forms of burners and blow-pipes.

Installations of this kind, using one or other of the patented forms of cell, were worked at Hanau, Cologne, Lucerne, Zurich, Milan, Rome, Tivoli, Brussels, Toulouse, Montbard, Paris, and Oloron Ste. Marie, and the gases were employed for various industrial purposes. The oxygen and hydrogen gases produced by the electrolytic process were, however, never entirely free from

THE ABSORBING TOWERS AT THE NOTODDEN NITRATE FACTORY

contamination, the hydrogen with oxygen and the oxygen with hydrogen, and a disastrous explosion of a cylinder of compressed electrolytic oxygen gas, last year in Switzerland, shook public confidence in the safety of the electrolytic method for preparing oxygen or hydrogen gas.

When worked with expert control and great care, the electrolytic method may be safely used, but in the absence of these the hydrogen contents of what is nominally oxygen gas may rise to 20 per cent. by volume, and this mixture is highly explosive and dangerous. The industry is, therefore, at present under a cloud, and it is questionable whether it will undergo further development until some more reliable device than the hanging diaphragm for separating the gases is introduced into the cells.

OZONE

The production of ozone by the silent electric discharge through oxygen or through air is similar in principle to the production of nitrous oxides by spark discharges. The electro-static method of ozone production has been employed for some years in connection with the sterilization of water and air, and with the treatment of food stuffs and similar products. A large number of different forms of apparatus for converting the oxygen of the air into ozone have been patented and several of them are now in industrial use.

The most successful and striking installations of this kind are those of the Siemens & Halske ozonizers for water purification at Schierstein and Paderborn, in Germany; but at Schiedam and Breda, in Holland; at Lille and Marseilles, in France, and at Philadelphia, in America, similar installations are to be found. Ozone, produced by the electro-static method, is also being employed near Paris and at Niagara Falls for the manufacture of vanillin from oil of

cloves. The ozone industry is likely to develop to a considerable extent.

PHOSPHORUS

Phosphorus is now produced at Wednesbury, in England, and also in Germany, by an electric furnace method, bone-ash being mixed with silicic acid and distilled at a high temperature in retorts of special design and material. It has been stated that the whole of the British output of phosphorus and one-third of the German are now produced by this electric furnace method, but no official confirmation of this statement can be obtained from the firms engaged in the industry.

In America, Machalske, of Brooklyn, is carrying out experiments with electric furnace methods of phosphorus production.

SODIUM AND POTASSIUM AND THEIR PEROXIDES

The production of sodium and potassium by the electrolysis of their fused hydrates has become a firmly established industry, and the writer believes that the whole of the world's supply of alkali metals is now provided by the electrolytic method. The Castner cell and process are most usually employed, and installations of this are to be found in England, at Weston Point; in America, at Niagara Falls, and at more than one place in France and Germany. The manufacture of cyanides and peroxides from the sodium obtained in this way is another branch industry which has been taken up by the electrochemical works, and large amounts of these salts are now turned out annually. Oxone is the name given to one of these products by the Niagara Electro Chemical Company, which also produces calcium peroxide, magnesium peroxide, and zinc peroxide. Oxone is fused sodium-peroxide, and, on contact with water, yields oxygen gas. It is, however, far more stable than the ordinary sodium peroxide.

TIN

Electrolytic methods have not been applied in the tin extraction or refining industry, but they have been employed in two branch industries with some success. Tin can be stripped from scrap and cuttings by aid of electrolysis, and this tin-stripping industry has become one of some magnitude and importance. In Germany a firm at Tostedt is also reported to be using an electrolytic method for extracting tin from slags. The tin-stripping process depends upon the use of the scrap tin as anode material in a bath of sodium hydrate. The chief development of the process has occurred in Germany, where seven factories are reported to be in operation, consuming 30,000 tons of tin scrap per annum. Similar factories have been erected and worked in Denmark, Austria, Great Britain, and America, but considerable difficulty is found in obtaining adequate supplies of raw material for the process, and some of the smaller factories have been obliged to suspend operations on this account.

Goldschmidt, of Essen, during 1905 patented a method of making old tin cans from town refuse suitable for the tin-stripping baths, and this may help to widen the area of supply. The industry is a stable and progressive one when under wise and expert management.

ZINC

Although many attempts have been made to apply electrolytic methods to the extraction and refining of zinc, only one process is known to the writer to be still in operation upon an industrial scale. This is the one patented by Hoepfner. It is in use at the Winnington works of Messrs Brunner, Mond & Co., in England, and in Austria. By this process zinc chloride is electrolyzed, and the chlorine obtained as the gas at the anode is converted into bleaching powder. Owing to the

excessive production of chlorine compounds by the electrolytic alkali works, the Hoepfner process is not developing.

Electro-thermal methods of treating zinc ores are, however, coming to the front, and at Sarpsborg, in Norway, there is an installation of the de Laval furnace and process which has turned out over 2000 tons of zinc. A company has been formed in Belgium to exploit the de Laval process in Europe, and negotiations are now under way for its introduction into America. The zinc produced by the de Laval furnace and process is of high purity, and competes easily in quality and price with the purest brands of zinc made by the older metallurgical process. The electro-thermal methods of zinc extraction may, therefore, have a great future.

The Swinburne-Ashcroft process, which is now in operation at Weston Point, England, upon a scale of 30 tons of ore per week, is not an electrolytic process as at present worked, for the zinc chloride is sold as such, and is not separated by electrolysis into its constituents,—zinc and chlorine.

THE METRIC SYSTEM FALLACY

WHY COMPULSORY METRIC SYSTEM LEGISLATION SHOULD BE DEFEATED

Opinions of Leading Engineers and Manufacturers

THE metric system fever is a bit like the measles. It makes its appearance every once in a while, and it generally also passes off without evil effects. One has become used to not considering it seriously.

At present, however, with the compulsory metric system bill being vigorously pushed at Washington, and the Decimal Association working towards the same end in Great Britain, the situation has undergone a change. We are now threatened, more seriously, perhaps, than ever before, with the enactment of a law which within certain limits would force the metric system upon many unwilling officials and manufacturers and which would work widespread mischief in all English-speaking countries. Therefore, however well the pros and cons of the metric discussion may have been thrashed out in the past, the subject demands, unfortunately, renewed consideration now. It has ceased to be simply interesting; it is instead a menace to the welfare of British and American manufacturing industries. Certainly the threatened legislation, prompted by misguided effort and ignorance of practical considerations, should be buried so deep by opposing opinion that its resurrection, if it come at all, should be in the very distant future.

The literature of the subject is voluminous, but the gist of it all was excellently presented by Mr. Frederick A. Halsey in a lecture delivered at Cornell University last year. Mr. Halsey has laboured unremittingly in defence of established English standards of measurement, and in this lecture summed up the situation in a way which at this time is particularly worthy of still wider publicity than it has already received; hence it is here again reproduced.

In addition, the opinions are given of a number of well-known engineers and manufacturers in the United States, where the metric agitation is just now waxing livelier than anywhere else. These were received in

response to invitation by the editor of this magazine, and help to emphasize the fact that the man engaged in manufacturing business, the man who does things that add to the industrial development of the country, and who has material, and not simply scientific interest at stake, is the one who does not want metric legislation.

As to conformity with the ways of the world, it is well to remember that there are 567,000,000 people inhabiting the countries in which the metric system is not used, as against 445,000,000 people in countries where the system is used, according to official announcement, and in many of these latter, it should further be remembered, the use of the system is, after all, only superficial, that is, commodities may be sold by the meter or the kilogram to satisfy the law, but they are manufactured by the yard and the pound, or by any of the other units of measurement which may have previously been in use in the particular countries under consideration.

There is not enough space available in this issue for the many protests against the metric system that have been received. But as they all are interesting, and illuminate the subject from many different individual points of view, they shall be presented in the June number of this magazine.—The Editor.

MR. FREDERICK A. HALSEY ON THE METRIC SYSTEM

I SHALL have little to say about the merits or demerits of the metric system, my aim being rather to show the difficulty of displacing a system of weights and measures which has become incorporated in manufacturing industry. The pro-metric forces are made up chiefly from the ranks of scientific men, while the anti-metric forces are made up chiefly from the ranks of constructors and manufacturers.

An explanation of the reason why these parties look upon this matter so differently is, I consider, the most important matter connected with this controversy, and I shall endeavour to give such an explanation, and to show that because of the radical difference in the use of weights and measures by these two parties, the scientific man's experience and opinions have no application to the manufacturer's problems.

The scientific use of measurements consists in measuring existing things; the industrial use of measurements consists in making things to certain sizes. In the scientific use we have given the thing of which we find the measure; in the industrial use we have given the measure to which we make the thing.

Parallel with this difference we find this division of sentiment, for between those who measure things and those who make things is the line of cleavage. Such a broad, clear line of demarcation seems to me a very significant thing, and instead of dismissing opposition to the system as due to ignorant prejudice, fanaticism and blind partisanship, as is habitually done, it seems to me to be more in accord with the spirit of science to examine the difference between these two kinds of measurements in order to determine if therein there may not lie a satisfactory explanation of the opposite attitudes of these two parties, and this I shall endeavour to do.

A typical illustration of the scientific use of weight and measure is found in the chemist's balance. The chemist places a substance upon one pan of his balance, and proceeds to balance that substance with his weights

and his rider. This is the exact opposite of the grocer's use of his balance, for the grocer places his weight upon the scale pan first, and proceeds to balance that weight with the required amount of material. This weighing out of a specified amount of material by the grocer is closely analogous to the making of things of specified sizes, and by comparing these two kinds of weighings we may quickly pass in review the salient points of difference between scientific and industrial measurements.

The chemist has given a mass of material of which he finds the weight; the grocer has given a weight of which he finds an equal mass of material. The chemist finds the weight of a given mass; the grocer finds the mass which has a given weight. The chemist finds the weight, but the weight is the very thing which the grocer has given in advance. Each, in fact, finds what the other has given, and each has given what the other finds.

The weight found by the chemist is a matter of pure accident; that is, while, like everything else subject to the laws of Nature, it is, so far as his individual control of it is concerned, a matter of simple chance. The weight used by the grocer, on the other hand, is a matter of deliberate choice. This power of choice, this ability to say in advance what the measurements shall be, is the turning point in this whole matter. The constructor always has it, the scientist never, and hence they differ upon this subject. This is my thesis.

Comparing the apparatus used by the two parties, we naturally find that each is adapted to its purpose. The chemist sets out to find any weight whatever within the range and capacity of his apparatus. His balance is, therefore, fitted to find any possible fractional weight down to the minutest difference under which the beam will turn. The grocer's weights, on the contrary, have no reference to the sensitiveness of his scales, but only to the wants of his customers. From whatever standpoint we examine these two kinds of weighings, we find them the exact opposites of one another,—and this regardless of their relative accuracy, which is a difference of degree only.

If the chemist's balance is sensitive to the tenth of a milligram, he is equipped for dealing with ten thousand fractions of a gram, but under the exercise of his power of choice this great number is cut down in the case of the grocer to three,—one-quarter, one-half and three-quarters of a pound, or of an ounce, as the case may be, for he deals with no fractions whatever but these.

It is not surprising that a system of notation which is satisfactory when dealing with three fractions fails to be satisfactory when dealing with ten thousand; it is not surprising that when dealing with ten thousand fractions requirements develop which are absent when dealing with three, and this is exactly the situation. The chemist has chosen to use decimals because for the miscellaneous fractional quantities with which he deals vulgar fractions would be hopelessly cumbersome; while for the few fractions with which he deals, the grocer finds them entirely satisfactory,—decimals being, for his quantities, the more cumbersome.

Summing up, then, we find the basic differences between these two kinds of weighings to be that while the chemist deals with many fractions, the grocer deals with but few, and, what is much more important, that while the weights determined by the chemist are matters of accident, the weights used by the grocer are matters of deliberate choice.

These differences run through all scientific and industrial applications of weight and measure. The scientist always measures things as they are; the constructor always changes them to sizes which are required. The measurements of the former are al-

ways matters of chance; the dimensions of the latter are always subject to deliberate choice. The scientist, like the chemist, must always be prepared to deal with all possible fractional values; the constructor, like the grocer, deals with a few selected fractions only.

It is the starting point of all organized manufacture that of the many possible sizes but few shall be actually used. Measuring to thousandths of an inch only, we might have, between one and two inches, a thousand diameters of screw thread. As a matter of fact, of standard threads we have but eight, while of standard shafting we have but four, and of standard pipe but three. These few sizes correspond with the grocer's few weights, and, like them, they are the result of this exercise of choice. Like the grocer, the constructor deliberately chooses these few fractional sizes, and discards all others, saying he will not use them, except, of course, when necessity compels, and even then he uses but few of the many sizes that he might use. This limitation of manufactured things to a few of many possible sizes characterizes all branches of manufacture and has always done so. We see familiar examples of it in our wearing apparel. Our collars, cuffs, shoes, hats and gloves all illustrate the same principle.

THE SCIENTIST'S AND THE CONSTRUCTOR'S CALCULATIONS

The measurements which result from scientific observation form the data on which calculations are based, while the constructor's dimensions are the results of his calculations, these calculations being undertaken in order to obtain them. To this rule there are some real and more apparent exceptions, and if anyone is disposed to quibble, I am opening wide the door; but, broadly speaking, it is true that scientific measurements enter calculations at the beginning, while the constructor's dimensions appear only at the end of his calculations.

To simplify calculcations the arithmetical notation in which the former are expressed is, therefore, a matter of large importance, while for purposes of calculation the notation in which the latter are expressed is of very small importance, and this is increasingly evident when we consider again the result of this exercise of choice; for the constructor seldom uses the exact results of his calculations. He must choose between a 6 and an 8-inch pipe, as he must choose between a 10 and a 12-inch I-beam. For smaller work the English system constructor chooses the nearest eighth or sixteenth of an inch, as the metric system constructor chooses the nearest tenth or fifth of a centimeter. Now just how calculations are to be simplified by choosing the nearest tenth in preference to the nearest eighth,—the choice being made after the calculations are finished,—has never been satisfactorily shown.

"The primary object of a system of weights and measures is to weigh and measure," not to facilitate calculations, and if we were charged with selecting a set of sizes for use in manufacture, our first consideration would be their suitability for the purpose,—the arithmetical notation in which they are expressed being entirely secondary. The series of sizes resulting from the binary system of division is in the highest degree satisfactory, while the series resulting from the decimal system is unsatisfactory.

Regarding these two systems of division simply as giving systems of sizes and without regard to any system or notation, the binary scale is distinctly superior, while the binary system of fractions is entirely satisfactory, so long as we are at liberty to choose for use the sizes which they express, but no longer. So long as we are at liberty to choose one-half, one-quarter, one-eighth, and their multiples of an inch or of a

pound, so long do the fractions $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, and their multiples form an entirely satisfactory system of notation, far more so than their decimal equivalents; but the instant this power of choice is removed and we have to deal with miscellaneous divisions, these fractions become hopelessly impossible. Hence, the constructor who has this power of choice keeps these fractions, while the scientific man, who is without it, discards them. It seems to me the tremendous importance of this power of choice should by this time be apparent.

It should be noted, however, that the binary scale is unsatisfactory for scientific use, not because of any inherent defect, but because it is yoked to our decimal system of notation with which it is out of harmony. I presume there is not a person in this audience who does not know that as a basis of notation 10 is an unfortunate choice,—better than 9 or 11, but not to be compared with 8 or 12. When dealing with all possible fractional values the first requirement is conformity of the system of division of units with the established system of notation, regardless of its merits or demerits, and in his choice of decimal divisions the scientific man does not pass upon the fundamental merits of decimals, his decision being due to the necessity for this conformity. The same necessity for conformity would be felt were our notation based on 9 or 11.

THE EXAMPLE OF THE CIVIL ENGINEER

The metric party has frequently turned to the fact that the civil engineer divides his foot into tenths as an example of the confessed superiority of decimal divisions; but this citation, like most others, turns against them when properly examined. The civil engineer divides his foot into tenths for purpose of surveying, that is, measuring. For purposes of construction he divides his foot into inches like everybody else.

For an explanation of this, go back to my initial illustration of the chemist and the grocer. The civil engineer divides the foot of his leveling rod into tenths because, when using that instrument, like the chemist he measures things as they happen to be; he must be prepared to measure any possible fractional dimension; his measurements are primary measurements which enter his calculations at the beginning. They are thus subject to all the conditions of scientific measurements. On the other hand, he divides the foot of his construction scales into inches, because when using those instruments, he, like the grocer, uses but few fractional sizes, which are subject to deliberate choice. He has deliberately changed the divisions of his measuring scales because he has found it advantageous so to do, and he has just as deliberately left his construction scales unchanged because he has found no advantage in the change. If a case had been made to order to illustrate the points I have been making, it could not possibly be more apt than this.

Of course, what these things show is that things are out of joint; that it would be idle to deny. We have this perfect binary system of sizes yoked to our very imperfect system of decimal notation, and hence we find that usage vibrates toward or away from the use of decimals, according as conformity with our system of notation, regardless of its merits or demerits, is or is not of paramount importance. Were our notation based on 8 instead of 10, what is now discord would become harmony, and in the last analysis the metric system is an attempt to secure harmony, but an attempt made through the sacrifice of the essentially good to the essentially bad.

THE ANTI-METRIC CASE

Having shown why the constructor and the manufacturer do not actively favour the basic principle

of the metric system, it remains to show why they oppose the introduction of the system as they do, and here again we shall find the explanation to lie in this fundamental difference between scientific and industrial measurements.

The opposition to this system arises from the fact that its adoption involves a complete change in this established list of sizes upon which all mechanical manufacturing is based; it involves the discarding of sizes which are shown by the lines on English scales and the substitution therefor of the sizes which are shown by the lines on metric scales, and there you have the anti-metric case in a nutshell. This difficulty is peculiar to industrial measurements; there is nothing to compare with it in scientific measurements.

To us this is the commonplace of commonplaces; absolutely simple, perfectly obvious, painfully elementary; but it is exactly what we cannot get the scientific man to understand. You may search scientific pro-metric literature almost in vain for so much as a reference to this matter; you may search it absolutely in vain for any discussion of it which is entitled to be called by that name.* Scientific pro-metric literature recognizes the break in technical literature, and it discusses this very, very gingerly, though it does recognize it; and it also recognizes the expense of new weighing and measuring instruments, learning to use them, and learning to think in the new units, and it recognizes no other difficulty whatever. These difficulties, you will observe, are precisely what the scientific man would have to face were such a change impending in the scientific world to-day. They are not the beginning of the manufacturer's difficulties,—they are the measurer's, not the maker's difficulties.

*One of the most pretentious defences of the system ever made is "The Metric System," by Dr. F. A. P. Barnard. Part II. of this book is entitled, "Objections to the Metric System Considered," and it does not contain so much as an allusion to this difficulty, which is chief of all.

From the standpoint of the manufacturer this change in the list of established sizes to which things are made is almost the only thing worth discussing; it is precisely the thing which scientific pro-metric literature does not discuss at all. And those who know so little of the subject that they do not even recognize the chief point at issue speak as with the authority of a Moses, and tell us that our case is based on ignorance and prejudice; and when we resent it, they reprove us for our bad manners and our intemperate language. And all because this exercise of choice resulting in a defined list of sizes to which things are made is foreign to the scientific use of weight and measure and foreign to the scientific man's conception of the subject.

You will observe that the effect of such a fundamental change as this upon manufacturing industry is especially and peculiarly a manufacturer's question; you will observe that it is not in the smallest degree a scientific question; you will observe that there is nothing in the scientific man's knowledge, training or experience to qualify him to speak with authority upon it. I have observed that his knowledge, training and experience do not lead him to so much as recognize its existence. And yet for a century the scientific world has presumed to assume charge of these matters and to brand with ignorance all who differ from it.

DIFFICULTY OF CHANGING UNITS OF LENGTH, WEIGHT AND CAPACITY

This difficulty relates chiefly to measures of length. The easiest of all measures to change are those of capacity. Next come measures of weight, which in some applications are as easy to change as are those of capacity, while in others they are as difficult to change as those of length, and lastly, all things considered, come measures of length. As an example, go to the works of the Solvay Process Company, at Syracuse,

N. Y.,—a company which has been heralded far and wide as having adopted the metric system. It is true that at its organization that company did adopt the system, and it has continued to use the liter and the kilogram without serious difficulty,—without any difficulty, if you so prefer it,—but it has been compelled to abandon the meter. Why? Because units of weight and capacity in their chemical application are comparatively easy to change, while units of length in their mechanical application are extremely difficult to change.

The experience of the world is the same as that of the Solvay Process Company. It is a fact that the liter and the kilogram are far better established in the world's commerce and industry than is the meter. Of course, the average metric advocate does not know this, and when he is told, he can see no significance in it, although, as a matter of fact, there is nothing in the whole history of the system that is more significant than this.

I believe there is no instance in modern times in which a unit of length once anchored in manufacturing industry or in titles to real estate has ever been entirely supplanted.

ILLUSTRATIONS OF THE PERSISTENCE OF OLD UNITS

Even the barleycorn is in wide use to-day, for the difference between the sizes of our shoes is a barleycorn. The State of Texas has been United States soil since 1846, but in those portions of the State which were settled by the Spaniards,—how it is in the other portions, I do not know, nor does it matter,—the common unit of land measure to-day is the Spanish vara. In Louisiana the corresponding unit is the arpent,—the old French unit,—which, in spite of a century of compulsory laws, is still current in France, and which, anglicized in pronunciation, is, to-day, the common unit by which land is bought and sold in Louisiana.

In the older parts of Philadelphia 100 feet and 3 inches are to-day legally 100 feet, because the surveyor's chain with which that city was laid out was three inches too long. Special tape lines are made for use in Philadelphia on which 100 feet 3 inches are graduated as 100 feet.

The ½-inch United States or Sellers standard screw thread has 13 turns per inch. Mr. Welsh, the original superintendent of the Westinghouse Air Brake Works, for some reason, now unknown, objected to an odd numbered thread, and he, therefore, adopted the Sellers standard, except that for the half-inch bolt, he adopted 12 threads instead of 13. This decision has proven to be a mistake and a nuisance, and the company would to-day be very glad to change it, but it finds itself powerless to do so. The immense number of brake equipments, which are out all over the world, the constant call for renewals, repairs, and extensions makes the simple necessity for continuity paramount above all others. I know of no more significant example than this. This great company finds itself powerless to change the number of threads upon one size of bolt by one turn per inch, but our metric friends tell us that we can change everything and almost without difficulty.

THE METRIC SYSTEM IN EUROPEAN TEXTILE MILLS

The average observer in metric Europe finds that goods are commonly, though by no means universally, sold across the shop counters by metric units, and he concludes that the system is in universal use, but he knows nothing of what goes on behind the factory doors and he does not ask. He does not know, for example, that the very silk fabrics which are sold across the shop counters of Paris by the meter are made in the mills of Lyons by the aune,

the denier and the old French inch. He does not know that the cotton fabrics which are sold across the shop counters of Berlin by the meter are universally made in German mills by the English yard and the English pound. He does not know that the woolen fabrics which are sold throughout metric Europe by the meter are made with the help of ten different pounds and twenty-one different ells.

Do you doubt my statements? Then I will read from a recent article in "L'Industrie Textile," by M. Paul Lamoitier, who is one of the collaborators of that paper, the author of important textile books and a textile expert. Says M. Lamoitier:—

"We are as much in the anarchy of weights and measures for the textile industry as at the time of the Revolution, for we have the denier of Montpelier and of Milan for silk with the aune, as a unit of length. We have still the diverse standards of Roubaix, Fourmies and Reims for worsted, the moque of Sedan, the livre, the quart and the sous of Elboeuf, the yard for linen, etc."

Again, I will read from the preface of a recent Austrian textile book:—

"The English system is at the present time introduced into the greater part of Europe (including Austria-Hungary), in North America and in other countries; it likewise is the basis for the tariff on cotton yarn in Austria-Hungary, Germany, Greece, Russia, and Spain. This English system is also the basis for the following calculations (in this book), and we will refer to the French and international (metric) systems only for comparison."

It is to be understood, of course, that this reference to the use of the English system refers chiefly to its factory rather than to its commercial use.

The metric advocate knows nothing of this, nor of the hopeless tangle of confusion which is involved in the conjoint use of different systems of measurement, and to illustrate this, I will read a description of a recent German yarn table:—

"The Austrian weaver runs his eye down the columns headed English yarn number, until he reaches the line at the left of which is the set in threads per Vienna inch, and there he finds the weight in English pounds of the yarn he needs for 100 meters of cloth 100 centimeters wide."

You will observe that there is nothing whatever in this table which is metric except the dimensions by which the goods are sold,—the mill units being entirely non-metric.

In order that the last and the next quotations may be understood, the term "yarn counts" should be explained. Yarn counting or numbering is a system of denoting the size of the yarn in terms of its weight and length. The number of counts of a given yarn indicates either the length of a fixed weight or the weight of a fixed length. We see every day examples of this in the case of spool sewing cotton. In case the units of length and weight are English, the yarn counts are English, whereas if those units are metric the yarn counts are metric. The yarn numbers are the fundamental units of the textile industry and are at the base of all manufacturing operations and of all estimates and cost calculations. The next example shows how a German textile manufacturer determines the cost of a simple piece of cotton tape as wide as your finger:—

"The reed is gauged by the number of dents per French line. The yarn counts in both warp and filling are English, based on the 840-yard standard. The picks of filling are given as so many per French inch. The weight of the warp yarn is calculated in metric grams from the English counts and extended at a price in marks per English pound. The length of the filling yarn is calculated per 100 meters of cloth from the picks per French inch, and the width in French lines. The

weight of the filling in grams is then calculated from the English yarn count and the length in meters. This weight in grams is then extended at a price in marks per English pound."

The above quotation, which can be duplicated almost without limit, is not an illustration of the demerits of the metric system, but of the tangle of confusion which results from a mixture of systems. Either system would be good enough alone, but their mixture is intolerable.

You will understand that this book from which I am quoting* is packed with facts of this kind, limitations of time preventing my picking out more than a few cases to make a connected story.

THE METRIC SYSTEM IN MEXICO

The next illustration comes from Mexico, and shows the manner in which the value of a lead ore, carrying also gold and silver, is determined in Mexican smelters.

"When the ore contains 5 per cent. or more of lead, it is paid for at 1 cent United States currency per pound when soft Spanish lead is quoted in London at 13 pounds sterling per ton of 2240 pounds. For each advance or decline of 1 shilling, 3 pence in the London quotation, 1 cent United States currency per 100 pounds for lead contents will be added or deducted. The ore, however, is weighed and deliveries are made in kilos, and assays are reported per metric ton of 1000 kilos. The silver is paid for at 90½ per cent. of the New York quotation, which is in United States currency per troy ounce. The gold, however, is paid for at $0.6269 United States currency per gram. Freight and treatment charges are $24.50 Mexican currency per ton of 2000 pounds avoirdupois."

And this is in Mexico, where it has been illegal to use anything but the metric system for twenty-five years, and where the House Committee on Coinage, Weights and Measures were told that the system is "working magnificently," and the irony of it is that this information came through the Mexican Minister of Mines!

When we point out cases of this kind the metric advocates say, "But how much better it would be if they would use the metric system," that is, if they would use it exclusively, and to this we reply:—How much better it would be if they did not use it at all; how much better it would be if this mistaken attempt to introduce it, which has done nothing but increase prevailing confusion, had never been made.

I could give you a lot of things from Mexico. For instance, I was recently told in the office of Mr. Becker, the maker of chemist's balances, that he is to-day called upon to supply chemist's balances for Mexico, fitted with the old Spanish weights, for they have three systems of weight and measure in Mexico. Their historic system is the Spanish, while the English system has been carried there by the resistless forces of trade and commerce, and superimposed upon both by force of law is the metric system. In Mexico to-day it is the usual practice to sell so many kilograms of 1-inch bar iron, so many meters of 1½-inch pipe, so many square meters of 1-inch lumber, so many kilograms of 12-pound (that is, 12 pounds per yard) rails; and as regards pipe and lumber, the practice is paralleled in Germany, where wrought iron pipe is made and measured to English sizes and lumber is also sawn to inch dimensions.

Do these facts jar upon your conceptions of the wonderful simplicity of the weights and measures of metric countries? If so, it is because those conceptions are based upon the fairy stories which comprise the bulk of the pro-metric literature,—fairy stories of which the foundation is the baseless fabric of many, many

*The Metric Fallacy and The Metric Failure in the Textile Industry. The textile information is due to Mr. S. S. Dale.

dreams. For concrete illustrations of, and object lessons in, "The Scientific Use of the Imagination," read any piece of pro-metric literature.

THE METRIC CASE IS BASED UPON AN UNTRUE ASSUMPTION

The entire metric case is based upon the tacit assumption that with the adoption of the metric system the old units will quickly disappear. This has never been the case, and there is no prospect that it will ever be. The metric units are simply superimposed upon the old units. "Nothing is so easy as to introduce a new unit of measurement; nothing so difficult as to get rid of an old one." The attempt to get rid of old units by the addition of new ones is simply an attempt to obtain the result of subtraction by the operation of addition, and we ought not to be surprised that the attempt fails.

We have a perfect example of this in our two tons. Many years ago the attempt was made to get rid of the 2240-pound ton by adopting the 2000-pound ton, but somehow the old ton persists in use, and to a much greater extent probably than most of this audience suppose,—gross products, especially at wholesale, being commonly sold by the old ton. The result is confusion, and we frequently find it necessary to specify whether we mean the long or the short ton, and in the absence of such specification uncertainty constantly arises.

The metric programme is to get rid of these two tons by adding a third, the metric ton of 2204 pounds, the metric theory seeming to be that two plus one equal one, whereas, in these matters, like all others, two plus one equal three.

THE PARAMOUNT IMPORTANCE OF CONTINUITY

We have thousands of cases like the Westinghouse bolt. Some of these represent the practice of the entire country,—for example, screw threads, pipe, shafting, bar iron, and the thicknesses to which lumber is sawn. Others represent entire industries,—for example, the numerous railroad and Master Car Builders' standards, by which interchange of railroad cars throughout the country is facilitated and in many cases made possible. Others, again, represent individual factories. In all, the basic principle is the same,—the simple necessity for continuity is a thousand-fold more important than all the disadvantages which can be claimed for the making of these things to metric instead of English sizes. The laborious efforts of the past forty years toward standardization in all branches of mechanical work are simply efforts to secure and to assure this continuity.

Consider for a moment the importance of uniformity in the various coupling devices between railroad cars for connecting the cars, their steam and air hose. It is by this uniformity that the interchange of cars throughout the country is made possible. Destroy this uniformity, and this interchange becomes impossible, and it seems to me that it ought to be plain to anybody that such a change is impossible. I wish I could give you an adequate picture of the infinite effort which has been the price of the present uniformity and then contrast it with the simple-minded manner in which the metric advocates propose to throw the results away in the pursuit of a simple fad.

These things will not be changed because they cannot be. Should the attempt be made, the result will be here what it has been elsewhere,—a partial change. We will make the easy, but not the difficult changes, and between the two will be an ill-defined region in which changes will be constantly attempted; sometimes with success, sometimes with failure, always with confusion. The changes made here will be fewer than elsewhere because of the immensely greater development of manufacturing here than in any metric country

at the time when the system was adopted.

The result of this conjoint use of two systems will be here what it has been elsewhere, an infinite number of conversions and re-conversions between incommensurate units, in the face of which any possible theoretical advantage of any possible system will be hopelessly lost. Examples of this have been given in the citations which I have made from European textile and Mexican smelting calculations, which all represent precisely the condition which I have described,—the easy changes have been made, but the difficult ones have not been.

ENGINEERING CALCULATIONS DURING THE TRANSITION PERIOD

Structural shapes and other standardized things will certainly not be changed until the demand arises, because such changes cost money and iron mills are in business to roll iron to suit the prevailing demand, and not to lead in reform movements. The demand for a change must come chiefly from engineers, architects and shipbuilders, and I suppose the most ardent metric advocate would admit that there will be some delay before this demand becomes effective. All admit that there must be a period of transition of greater or less length during which both systems will be used; and let us see what it will be like in engineering work.

Since the initiative must be taken by engineers and others in allied lines of work, they must begin by using material made to the present sizes. Imagine an engineer under these conditions finding the load which a bar of iron will carry in tension, the load being in kilograms, but the iron available made to inch dimensions. He is at the start confronted with questions of stress and strength in kilograms per square inch, but we have no tables upon this basis. We have tables giving the strength in pounds per square inch, and in kilograms per square centimeter, but none giving the strength in kilograms per square inch. Our engineer, therefore, converts his inches to millimeters, and consults a metric table, but he finds that the size that he has obtained is not there, because English and metric sizes are not alike. He, therefore, interpolates between the nearest metric sizes and obtains the desired result. Looking back over the process, he finds that in this simplest of cases he has made one conversion and one interpolation in order to find a result which, with either system used alone, he would take direct from the table without any calculation whatever.

As another illustration, consider the calculation of the discharge of water through pipe. The head, the length of pipe, and the velocity are given in meters, and the discharge in liters, but the diameter of the pipe is in inches. Again, we have no table fitting this condition, and we convert our inches to metric dimensions, again to find that the resulting dimension is not in the table, and again we interpolate, the result being as before, that we perform one conversion and one interpolation in order to find what, with either system alone, we could take direct from the table without any calculation whatever.

Consider next the determination of an I-beam to carry a given load. Our span is in meters and our load in kilograms, but the cross-section of our beam is in inches. What shall we do with the moment of inertia? Remember that in the moment of inertia of an I-beam, four dimensions enter. We must, therefore, interpolate not for one dimension, but for four, two of which enter the formula by the first power and two by the cube, and with the wide intervals which prevail between different sizes of I-beams it is scarcely safe to interpolate by simple proportion for quantities which enter the formula by their cubes.

Moreover, when we compare the English with the metric cross-sec-

tions, we shall find that, except by accident, no two of these dimensions bear the same proportion to one another. Under the circumstances we shall be compelled to abandon interpolation and to calculate the quantity from first principles, and at the end we shall be forced to recognize that all this labour is due to the conjoint use of two systems, and that with either system alone the result would be taken direct from the table without any calculations whatever.

TRANSITION LITERATURE NECESSARY

These conversions and interpolations appear at every turn of every piece of construction work. It seems to me plain that they would be intolerable, and there is but one way of escape from them. Before a beginning can be made some one must prepare a complete outfit of transition technical literature, in which general engineering quantities, such as loads, spans, velocities, etc., are given in metric, while ruling mill dimensions are given in English units, which literature, as time goes on and changes are made in mill sizes, would become obsolete in sections, and we should gradually approach a pure metric basis.

How long will this transition stage last? I do not know, for I am not a prophet; but I do know that the entire textile literature of metric Europe to-day is of precisely this character. I do know that they are writing,—mind, I say writing, not merely printing and using, but writing,—this transition technical literature in France to-day, a hundred and twelve years after the inauguration of this change, during most of which period it has had behind it the most drastic of compulsory laws. Of the labyrinthian maze of this literature I am unable to give you any idea that would approach adequacy. Its use involves a blind staggering among the incommensurate ratios, reciprocals, and conversions which the mind fails to follow, the process being one of mechanical application of incomprehensible rules.

Consider the trifling development of manufacturing industry a century ago, consider how even with this trifling development the old units have in some industries resisted all efforts to dislodge them, and then ask how much time will be required with the existing enormous development to complete a change begun at the present time. I believe that the history of the system justifies the expectation that such a change begun under present conditions will not be complete at the end of a thousand years, and this is why I fight the metric system.

THE SAVING OF TIME IN PRIMARY EDUCATION

The House Committee on Coinage, Weights and Measures of the Fifty-seventh Congress were told by Dr. S. W. Stratton, director of the Bureau of Standards, that "careful estimates made by experienced educators place the time saved by the adoption of the metric system from two-thirds to one year in the life of every school child." This statement has been repeated over and over again both in America and in Great Britain. How plausible it sounds,—"careful estimates by experienced educators",—how easily it passes from lip to lip and from pen to pen, carrying an air of authority and conviction as it goes, and all the while the grossest of exaggerations.

I have in my hand the "Course of Study for the Elementary Schools of the City of New York as adopted by the Board of Education May 27, 1903." On page 39 of this pamphlet I find a tabulated statement of the schedule of studies followed in the schools of New York. Each column of this statement relates to a year and each line to a subject of study, the entries opposite each subject being the number of minutes per week devoted to that subject during that year. The footings of the

columns are in all cases 1500, which is the number of minutes comprised in the school sessions of a week,—that is, 5 days of 5 hours of 60 minutes each. The figures for mathematics are as follows:—

Year:	1	2	3	4	5	6	7	8
Min. per week:	120	150	150	150	150	200	200	160

By referring to pages 28 and 31, I find that the seventh year is devoted to Algebra and Geometry. Part of the eighth year is also given to these subjects, but as the amount is not stated I will change all of the eighth year to arithmetic. The school year comprises 40 weeks, and $40\times\frac{120}{1500}=3.22$ weeks is the equivalent of the entire time spent on this subject during the first year. In the same way we may obtain the time to be charged to this subject for the other years and add them up thus:—

1st Year $\frac{120}{1500}\times40=3.2$ weeks.

2d " $\frac{150}{1500}\times40=4.$ "

3d " $\frac{150}{1500}\times40=4.$ "

4th " $\frac{150}{1500}\times40=4.$ "

5th " $\frac{150}{1500}\times40=4.$ "

6th " $\frac{200}{1500}\times40=5.33$ "

7th " Algebra and Geometry.

8th " $\frac{160}{1500}\times40=4.27$ weeks.

Total....28.8 weeks=6.63 months.

I think you will observe that these "eminent educators" will have some difficulty in showing how they are to save from eight months' to a year's time by omitting a part of less than seven months' work, and, mark, I have given you no one's estimate, but the actual practice of the largest system of schools on earth.

I have no figure for the percentage of this total time which is spent upon denominate numbers and weights and measures that can be called precise, and I do not believe that such a figure is obtainable,—this pamphlet, which represents, perhaps, the extreme of formalism in these matters, giving no clue to it. I have, therefore, gone at this in an indirect manner. By taking the school arithmetic* used by my own daughter and counting the number of pages devoted to denominate numbers and to weights and measures, I find that they comprise almost exactly 20 per cent. of the entire book,—a collection of miscellaneous examples and an appendix containing the various rules for partial payments, etc., which few study nowadays, being omitted from consideration. If we assume that the time spent upon a given division of a subject is proportional to the space given to it in the text-book, we have a ready means of determining the amount of time devoted to denominate numbers and to weights and measures. Such a method cannot, of course, be called precise; but, on the other hand, it cannot be far wrong, and if anyone will suggest a better method of getting at the facts, I shall be glad to follow it.

Making this multiplication we find $28.8\times.2=5.76$ weeks as the total time devoted to denominate numbers and weights and measures, and I think you will observe that the difficulties of the "eminent educators" are rapidly thickening; but this is not all. Were this bill passed tomorrow, and were it to work as expected by its promoters, we should still have with us the year divided into months, weeks and days, the day divided into hours, minutes and seconds, and the circle divided into degrees, minutes and seconds. We should still have the subjects of interest and discount involving the divi-

*Wentworth's Practical Arithmetic.

sions of the year, we should have longitude and time connecting the divisions of the circle with the divisions of the clock dial, and we should have our old land measures because the completion of the survey of the public lands is expressly exempted from the operation of this bill. To teach these subjects, we should still have to teach all the principles of denominate numbers together with their applications to these subjects, and by so much time as would thus be consumed, must the 5.76 weeks, found above, be reduced. I will not attempt to determine this, for certainly the case has been made sufficiently ridiculous already.

THE PROPOSED LAW HAS BEEN TRIED FOURTEEN TIMES

The metric bill, which is now before Congress, provides for the adoption of the metric system for government purposes in the expectation that the example of the government will soon be followed by the people at large.

This scheme of government adoption has already been tried for us fourteen times, and laws providing for such government use of the system are now in force in fourteen different countries. The results of these trials have been uniformly the same, viz., failure,—the system has remained the government system with little or no use of it by the people.

The first country to make this trial for us was Greece, which adopted the system in this way in 1834, and after seventy years of use of it by the government the old system remains in large use by the people. This statement is made on the authority of Mr. McGinley, United States Consul at Athens. The next trial of this kind, so far as my information goes, was made in the Philippine Islands, where the Spanish Government adopted the system for government purposes fifty-five years ago. It is to-day used in the custom house and other government businesses and on the railroads in the matter of shipments, but nowhere else. Dry goods, for example, are sold by English, Spanish, Chinese and Filipino units, but seldom or never by the meter. This statement is made on the authority of Rev. George G. Rice, chaplain of an American regiment in the Philippines.

The other countries in which this scheme has been tried are Nicaragua, Honduras, Venezuela, Cuba, Colombia, Guatemala, Panama, Santo Domingo, Ecuador, Egypt, Costa Rica, and Peru. The authority for the condition of things in these countries comes in most cases from United States consuls, sometimes from two or three consuls in the same country, and in the case where the information is not official it is of a nature which is equally trustworthy. This information is uniformly the same, viz., the system is used but little or not at all among the people. Nevertheless, everyone of these countries appears in every list of "metric" countries.

In view of the known facts, the claims that are made for the universality of the system are simply grotesque. They are worse than merely untrue,—they are ridiculous.

The metric advocates learn that in a certain country a metric law of some kind has been passed. What it is they do not know, and how it works they do not ask, but they immediately assume that because some such law has been passed, therefore the people have dropped their own units and taken up the new, and then, having proven so easily that the change is an easy one, they insist that there is no reason why we should not make it.

THE UNITED STATES A "METRIC" COUNTRY

If you will go to the right "authority," you will be surprised to learn that the United States is to-day a metric country. I have in my hand a copy of the "Bulletin of the

International Bureau of American Republics," in which I find this statement:—

"The metric system has been adopted by the following-named American countries:—Argentine Republic, Bolivia, Brazil, Chili, Colombia, Costa Rica, Ecuador, Honduras, Mexico, Paraguay, United States of America, and Venezuela."

This statement is printed from standing type, and appears in every issue of this Bulletin, as it has done for years, and twelve times a year it is sent to every Spanish-American country and under the imprint of the Government Printing Office at Washington. Where did it originate? It came from the same source as the remaining mass of fiction, which passes as fact in metric literature, viz., the vivid imagination of some metric advocate. As a simple matter of fact, it is no worse than many other fictitious pro-metric statements that pass current as facts, for we belong in the metric column quite as much as some of the countries which always appear there, the laws of which are simply permissive, exactly as is our own.

In Japan, which appears in every list of metric countries, for example, you may use the system if you wish without danger of going to jail, and that is pretty nearly the extent of the adoption of the system in Japan. In the case of our own country you know the statement to be absurd, while in the others you do not, and that is all the difference that exists between them.

This case simply illustrates how little is required to place a country in the metric column, and it will, I hope, explain why my language is severe and why I regard the metric case with derision.

ANTI-METRIC OPINIONS OF LEADING ENGINEERS AND MANUFACTURERS

From James M. Dodge, President of the Link-Belt Engineering Company, Coal Handling and Conveying Machinery, Philadelphia

I AM not opposed to the metric system. I am opposed, however, to any legislation which would make its use obligatory upon the "other fellow."

As the law now stands you can use it and I can use it. Why should we not be satisfied without insisting that "Tom Brown" should use it against his will? It seems a curious phase of human nature, manifested in its intensity in the days of the Crusades and the Inquisition, that believers are not content to enjoy their beliefs, but must go further and insist that other people shall enjoy, whether they want to or not, the same belief.

In all the metric controversy we have had professional men and non-combatants in the commercial battle coming out strongly with their views, and insisting that those in the thick of the fight of manufacturing and selling should take up another burden imposed by the theorist, devote a great deal of time and energy, suffer a great deal of inconvenience, and spend vast amounts of money to do a thing that they do not feel the need of or care to do. Poor "Uncle Sam" is suffering now from all kinds of unnecessary so-called safeguards which are thrown around him without his desire and to his great cost and financial disadvantage, and the passage of legislation which would make it obligatory, even for citizens who might wish to deal with the central government, to charge an extra price,

and be put to great personal and manufacturing inconveniences as well, simply sets the brakes a little tighter.

It seems to me that the whole question of compulsory introduction of the metric system is not the result of any crying need for the system, but springs from an innate desire to force every one to think as I do, with this exception, that enthusiasm is always on the side of those who are onlookers and not participants in the conditions which they wish to reform.

Some parents perpetrate cruelties and impositions upon their children ostensibly "for the good of the child," but in reality for the gratification of their own egotism.

Certainly the manufacturers should have some little to say as to whether or not the metric system be forced upon them by those who think they know what is best for the manufacturer from a theoretical standpoint.

Possibly an amendment to the proposed legislation, by which the government would agree to pay the cost of the introduction of the metric system in all manufacturing plants, would be an easy and happy solution of the whole question.

From Henry B. Binsse, President of the Binsse Machine Company, Machine Tools, Newark, N. J.

IT has always been clear to me that a compulsory adoption of the metric system would work incalculable injury to our entire industrial system, in that it would lead to great confusion and to useless expense.

The fundamental difference between the metric and the English systems is not to be found by an examination of the meter or of the yard. The difference is one of principle. The metric system confines the user to fixed and very limited choice of weights and measures, while the English system gives the fullest liberty to everyone to select and to use the system of weights and measures which he thinks is best adapted to his wants. The essential point of the difference, then, between the two systems is the difference between despotism and liberty, and for that reason the metric system has never found favour with a free people, and never will. It is, therefore, entirely unsuited to any English-speaking nation.

We hear a great deal of complaint from people who are not apothecaries, nor grocers, nor mechanics, nor jewelers, concerning the complexity of the English systems used by these trades. I would call attention to the fact that these complaints never come from an apothecary, nor a grocer, nor a machinist, nor a jeweler. In this country the man who uses this system is entirely satisfied with it, and when these trades want something better, under our free laws they are at liberty to adopt something more suited to their needs. The fundamental principle of the American, or rather English, independence is to allow everyone the fullest liberty compatible with the welfare of the commonwealth, and our system of weights and measures is in perfect accord with this foundation principle.

The advocates of the compulsory adoption of the metric system admit their failure to convince the users of weights and measures of the value of their proposition, and, after the metric system has been a legal system in this country for nearly forty years, having made absolutely no progress, they wish to force their notions upon the apothecaries, grocers, mechanics and jewelers, just as though these good people do not know their own business. It is a great virtue to attend to your own affairs, and not to

meddle with your neighbour's, and a free people will never submit to any compulsion in a matter of this kind. Of course, it is possible to force the use of the metric system upon government officials, but the nation as a whole will not be moved, but will be greatly annoyed by such legislation; and it will be a step which will have to be undone later on.

From Charles E. Billings, President of the Billings & Spencer Company, Machinists' Tools and Drop Forgings, Hartford, Conn.

I AM not opposed to the metric system of measures, weights, coinage, etc., as a system; but I do not consider it advisable or practicable to change from the present system to the metric system.

There are in use in this country to-day, in the manufacture of tools and machinery, millions of dollars' worth of special tools, jigs, fixtures, machines, drawings, and gauges, all made to the English standard, the changing of which to the metric standard would, in my opinion, be a practical impossibility.

If we were to adopt the metric system in our works (assuming it to be possible) it would be a matter of enormous expense to us as well as a great loss in the output of our products. In fact, we might as well decide to discard the old works entirely and build a new plant and equipment, including the employment of a new force of workmen educated to use the metric system.

Large sums of money have been expended to establish standards in such products as screws, bolts, nuts, taps, reamers, gauges, and innumerable articles of manufacture, and it would seem to me that the adoption of the metric system would throw the entire manufacturing industry of this country into a state of chaos that would result in practical paralysis.

From Charles S. Gingrich, The Cincinnati Milling Machine Company, Cincinnati, Ohio

FULLY realizing the advantages claimed for the metric system as a system for scientific computations, we do not believe that it would have any advantage in the mechanic arts. On the other hand, we are certain that it would present a great many disadvantages, not only during the transition period, but for all time to come.

The important fact that is always overlooked and entirely ignored by the pro-metric people, is, that in manufacturing we work entirely to standards. Whether we use the English system, or the metric system, or any other imaginary system (and better than the metric could be devised) we must select certain sizes which are either round numbers or aliquot parts of round numbers, and must adopt these as our standards and work to them.

Translating the dimensions which represent our present standards into metric dimensions, would not do. The metric system and the English system are hopelessly irreconcilable. A machine, a locomotive, a bridge, or a suit of clothes must be made to either one or the other. That the two systems cannot be reconciled to each other, in machine construction, is clear from the following table:—

English Inches	Metric Millimeters	English Inches	Metric Millimeters	English Inches	Metric Millimeters
1	25.4	1 3/8	34.9250	1 3/4	44.4500
1 1/16	26.9875	1 7/16	36.5125	1 13/16	46.0375
1 1/8	28.575	1 1/2	38.1000	1 7/8	47.6250
1 3/16	30.1625	1 9/16	39.6875	1 15/16	49.2125
1 1/4	31.7500	1 5/8	41.2750	2	50.8000
1 5/16	33.3375	1 11/16	42.8625		

Every one of the standards we commonly use has a fractional metric equivalent. Every machinery manufacturer, every engineer, and every mechanic knows that the use of these equivalents would prove impossible in every-day machine-shop work. With our present system we know that the next size larger than 1 1-16 is 1 1-8. How many men could remember that the next size larger than 26.9875 millimeters is 28.575 millimeters?

However, the above might seem arbitrary. Following is a table based on a fact which we are facing every day. We have some call for milling machine arbours made to a millimefor standard diameter.

Metric Diameter.	English Equivalents.	American and British Practice Hole Diameters.	Decimal Equivalents	Difference
16 mm	0.62992"	5/8"	0.625"	0.0049 2.
22 mm	0.86614	7/8	0.875	0.00886
27 mm	1.06299	1	1.	0.06299
32 mm	1.25984	1 1/4	1.25	0.00984
38 mm	1.49606	1 1/2	1.5	0.00394
		1 3/4	1.75	
50 mm	1.96850	2	2	0.03150

The first column shows the standards adopted in metric countries for diameters of holes in cutters, and therefore for diameters of arbours. The third column shows American and British practice. The columns "English Equivalents" and "Decimal Equivalents" reduce both of these to decimals of an inch for easy comparison, and the column "Difference" shows how far they are apart. Some of these seem to be nearly the same, as, for instance, 38 mm. vary by less than 0.004 from 1½ inch, but considering that milling machine arbours must not vary more than 0.0005 from the standard to which they are made, it is evident on the face of it that even this 38 mm. arbour could not be substituted for the 1½-inch arbour without also making a change in the entire cutter and small-tool equipment.

The above is submitted in evidence of the fact that a change in systems, if carried out, also means a change in standards, and this would have to be carried all the way through the large number of customers would still want machines made to the old standards. This would necessitate carrying a double equipment of everything,—drawings, patterns, standard and special small tools, jigs, fixtures, measuring devices, and also a double stock of all standard small parts of the product. We know of no plan by which we could evade this. The expense would be unbearable—it would amount to not less than one-fourth of our entire working capital. Besides, this would also have the effect of splitting our business into part English standards and part metric. Assuming that in a short time we would be making half of our product one way and half the other, shop. For a long time to come a this would be the most favourable condition, and would amount to this:—Where we now make 100 machines of a given size in one lot and at one time, we would be obliged to make them in two lots of 50; in other words, we would split up our manufacture, and would lose the large advantage of manufacturing in quantities.

The hardship would not fall on the manufacturer alone, but every mechanic would be obliged to purchase in addition to his present equipment, an entirely new set of scales, protractors, micrometers, etc., and after all this had been done, not a single thing would be gained.

We see no necessity for making the change. We have for a great many years carried on a large export business. The majority of machines which we export go to metric countries. France and Italy are at present very heavy buyers. We have never yet received a request for a machine made to metric standards,

so that we do not think our foreign business will be affected in the least, whether we continue with the English or adopt the metric system.

The fact is, that if the change were made, we would not be benefited at all. We do not see any chance of gaining the slightest compensation for the immense expense that a change in the system would put us to. Assuming that a sudden change were possible, and that a year from now we would have everything changed over completely to the metric system, we could not make a cheaper machine, we could not make a better machine, and we could not sell more of them. Then why should anybody ask us to make the proposed change?

From E. V. Cresson, Secretary of the George V. Cresson Company, Power Transmitting Machinery, Philadelphia

WE do not look favourably upon the adoption of the metric system, as all our material has been designed on the standard measurements which have been used in this country for many years. Our business is such in which various parts are produced in quantity and are carried in stock. For instance, we have on hand at the present time something like 20,000 pulleys which are bored to fit shafts of standard shafting size, and should the metric system be adopted, we and everyone else in our line of business would be obliged to practically double the amount of stock which is carried on hand, and the cost of doing this would be prohibitive.

The reason why it would be necessary to double the amount of stock is quite apparent, and that is, that all the shafting which has been sold in the past has been to the present standard scale, and one can also appreciate that people are from time to time adding new machines to their equipment, or making changes which necessitate a change in the size of pulleys, etc., and the same reason will apply to all the other parts which are carried in stock.

It can, therefore, be readily seen that the expense of carrying a double stock would be so great as to increase the manufacturers' fixed charges for carrying material on hand, thus making it almost impossible to continue business.

From Wm. Lodge, President of the Lodge & Shipley Machine Tool Co., Cincinnati, Ohio

REFERRING to the objection we have to offer to the passage of the compulsory use of the metric system, we beg to say that the United States Government is a large customer of ours, and while, of course, we could readily refuse to fill orders, because of our not carrying two systems of measurement in our shops, neither ourselves nor any other manufacturers wish to be put in such a position.

Were we obliged to carry two systems of measurement by reason of the passage of such a law—which, of course, must necessarily influence thousands of other people besides the government itself—the cost to our company alone, on a rough estimate, would be likely to exceed the sum of $50,000, in order to prepare us properly with all the measuring instruments necessary to carry out the building of machinery on the metric system plan.

This, however, would be only a small part of the resulting confusion by reason of our being absolutely obliged to continue the present systems for all product that has been

shipped to date and which is likely to be in use, in many cases, up to fifty years from date. Furthermore, the advantage to be obtained seems to us so trifling—so far as the betterment of the product is concerned, or so far as the duplication of machines, or parts, is concerned—that we should put this advantage at a very low figure indeed.

We doubt if there is any country in the world where the matter of duplication has been given more study than in the United States, and thousands of manufacturers are able to duplicate parts with the greatest nicety, either by reason of jigs or templates, or by reason of our system of the division of inches into thousandths, which enables us to make very close reproductions. You can imagine what confusion it would make to the user of agricultural machinery, sewing machines, typewriters and other machinery that is made absolutely on the duplicate plan, particularly when it is considered that it is impossible to get equivalents to the English measurement into the metric measurements.

All land measurements would also be affected, both for what is now existing and for all time in the years to come.

These remarks only crudely indicate what disastrous results would come from putting the proposed law in force.

From Gould & Eberhardt, Machine Tools, Newark, N. J.

WE are not opposed to the metric system as a system, but we are opposed to its compulsory adoption for use on all dimensions, as is proposed by the bill pending before Congress. We have occasion to use the system at infrequent intervals on certain parts of our machines, which we export, and have no difficulty in arranging to give our customers what they want in this respect.

Approximated roughly, we would say that of the component parts of our machines, not more than one piece in 10,000 has been required to be made in the metric dimensions. In the case of such machines as we have been asked to furnish, with certain parts scaled to metric dimensions (on automatic gear-cutting machines) the only parts that were affected were the cutter arbours, which are required to be sized to a given metric diameter, and this, we believe, has only been due to the fact that our foreign customers use foreign cutters with holes sized in millimeters; also the screw for setting the work for depth of cut has a dial graduated in millimeters for convenience of the foreign operator in setting his work.

It is needless for us to mention to you the confusion, to say nothing of the expense, which would be incidental to attempting to change over from our present English standard of measurement to the metric. We believe this to be the strongest argument against its universal adoption where the English system is in force.

From Spencer Miller, C. E., Chief Engineer Cableway Department, The Lidgerwood Manufacturing Company, New York

IT seems to me to be an infinite pity that all nations are not now employing the same system of weights and measurements. For the United States to adopt the metric system, unless Great Britain with all her colonies adopted it also, would put us out of harmony with the vast English-speaking race completely encircling the globe.

Should the metric system be adopted as the standard by the United States Government, the utmost confusion would prevail for a long period. For example, every trade catalogue would have to be reprinted with dimensions in the present system and the metric system at the same time. To do otherwise would be to lose trade from those buyers who would resent the abandonment of the system which they have thoroughly learned.

The confusion incident to the adoption of the metric system by our government would be so great that there would be an emphatic demand for the repeal of the law.

The fight for the repeal would be persistently fought, and I am sure in the end the law would be repealed.

Until Great Britain and her numerous colonies adopt the metric system, we should adhere to our present system.

From E. D. Meier, President of the Heine Safety Boiler Company, St. Louis

WHILE I am not opposed to the metric system as such, I am decidedly opposed to the methods adopted by some of its friends in trying to force it upon an unwilling people, against the protests of practical manufacturers who thoroughly understand the situation. As Professor Sweet has shown, there is a larger population to-day in the countries using the English foot and inch measure than in those using the metric system, and a very large number of the latter are people but very slightly interested in the mechanical arts.

The action of Germany in this matter is often quoted as an example. Now Germany is unquestionably one of the foremost nations in the mechanical arts and manufactures, and her example is entitled to much weight. But it must be remembered that when the formation of the new German Empire made a uniform system of weights and measurements imperative, there were almost as many differents weights, measurements, and coins in daily use as there were German States and principalities. Furthermore, her nearest neighbour and her best customers used the metric system. It was, therefore, much easier to adopt the metric system than to adopt any one foot and inch. But then Germany did not adopt the French money system, and certainly a uniform money system all over the world is fully as desirable as a uniform system of weights and measures.

To force American manufacturers to adopt the metric system by such laws as have been proposed would be equivalent to confiscation of many millions of dollars invested in tools, patterns, jigs, dies, etc., that is, it would, provided it were possible to enforce it, which it certainly would not be. Every man in our workshops, from the superintendent down to the rivet boy, is used to thinking in feet and inches, and you would have to make him over again before he could get used to figuring in a foreign measure.

Manufacturers who desire to sell their products into countries using the metric system exclusively can be safely left to find their own time and means for the change. Many would, no doubt, find it more convenient and cheaper in the long run to erect separate shops on the metric standard for their export trade. American manufacturers do not require to be forced by a paternal government into anything which is for their own interest. After all, their strenuous opposition to the attempts made to foist this system upon us, should be answer enough to the theorists who are trying to accomplish it.

All employers of labour have their hands full enough to adjust and re-adjust the ever-recurring labour question. To compel all our workmen to think and work on the metric system would simply add another very serious element of discord to present perplexities. This is a matter of such paramount importance that it alone should bar once for all this attempt to penalize our manufacturers.

Since going to press with the preceding pages, Mr. Halsey has favoured us with the following, supplemental to the foot note on page 41:—

"Since this lecture was prepared, the united opposition of manufacturing interests to the Littauer bill has compelled the metricites to recognize the basic reason for this opposition, and with one accord they have revived the idea of preserving existing sizes, but measuring them in millimeters, the final hearings of the House Committee on Coinage, Weights and Measures being largely devoted to the defence of this idea. To most experienced constructors the idea carries its own condemnation. Its hopeless impracticability is shown at length in 'The Metric Fallacy and the Metric Failure in the Textile Industry,' by Mr. S. S. Dale and myself, and need not be repeated here.

"It should be sufficient here to state that metric countries, with many times our own reasons for so doing, do not use it. The Germans, for example, with general dimensions given in millimeters, give the dimensions of Whitworth threads, which they regularly use, in inches. Obviously if this plan were possible they would do what we are told we will do,—express the dimensions of such screws in millimeters, and if they find it impracticable to follow this practice in isolated cases where it would bring about uniformity, much more will we find it impracticable as a universal practice.

"It may be stated as a law that to whatever extent the metric system has been adopted in manufacturing in any country, to the same extent have constructive sizes been changed; and conversely, to whatever extent old sizes have been retained, to the same extent have the units on which those sizes are based been retained.

"The humour of the situation is that whereas, at the beginning of these hearings at Washington, the adoption of the metric system was urged because it would better adapt our manufactured goods to the needs of foreign customers, the conclusion of the hearings found the metricites fairly falling over one another in their efforts to show that the adoption of the system would make no change in those goods!"

NEW BUSINESS FOR ELECTRIC CENTRAL STATIONS

HOW TO GET IT

By Fred M. Kimball

AS it is the expectation of every person who invests in the securities of a central lighting or power station that dividends will be earned and paid, and as the reputation and standing of the management is largely gauged by the net returns from the operation of the plant, it must be the principal object of those in control to sell the largest quantity of current which the equipment at command will furnish, having due regard to requirements of safety and uninterrupted operation.

As central stations were first organized to exploit electric lighting only, so, until within a very few years at least, the principal aim of managers, superintendents, and others connected with the business has been to develop the lighting load. A great deal of ingenious, painstaking, and aggressive effort has been put into this branch of central station work, with the result that nearly all stations enjoy a large output of current during those periods of the day when artificial light is required. During the remaining hours of the day, however, a very considerable portion of the machinery of many central stations is idle.

As fixed charges are substantially constant in their amount, whether the station be in operation four hours or twenty-four hours a day, and as the cost of labour, fuel, and other station expenses usually amount to considerably less than one-third the total cost of supplying electric current at customers' premises, it follows that any additional demands which can be created for electricity during the light-load hours of the day and night will at once add materially to the gross revenue of the station and very largely increase the net profits as well.

During the past ten years more and more attention has been given to developing uses for electric current other than for ordinary lighting purposes, and in the last two or three years especially a notable advance has been made by many operating companies in the direction of adding to their current output during other than the evening hours. It is my purpose to discuss briefly the general subject of developing new uses for electricity. Although a great deal has been written and said on the subject, perhaps its importance affords sufficient excuse for further agitation, and I shall, therefore, endeavour to outline some of the most essential steps which may be taken to achieve the desired end.

In the first place, from a commercial standpoint, we must regard the sale of electricity just as the merchant regards the sale of any commodity with which he undertakes to supply the community whose patronage he seeks. We may put it down as a fundamental principle of successful merchandising that the article or service for sale must meet

the expressed or latent needs of the people to whom it is offered, and that its use must be of real value to those who purchase.

Second, the seller must be prepared to furnish the service or commodity offered with a reasonable degree of promptness and under such conditions that it may be safely, satisfactorily, and profitably utilized.

Third, the community must be thoroughly apprised that the merchant is in business and seeks its patronage. He must keep his name and occupation prominently before the public and leave no opportunity neglected to acquaint it, through judicious advertising or otherwise, with the variety and merits of the commodities which he offers. The merchant must also keep in personal touch with his secured and prospective customers as much as possible, and practice those little amenities of business contact which go so far towards maintaining the entente cordiale.

Finally, his prices must be such that, on the one hand, they will afford him a reasonable profit when the risks of his business and the inherent value of his commodity are considered; and, on the other hand, must not be so excessive as to largely limit the volume of his business.

It is quite immaterial that a commodity be suited to the needs of a community and desirable for it to purchase, or that the offering is moderate in price, if the community is not made aware that it is for sale and intimately informed as to its uses and merits. Therefore, if the merchant, through indifference or otherwise, fails to make buyers know and appreciate both the value of his merchandise or service and that he is able to supply it, he will achieve but mediocre success.

As the central station business is really but one form of merchandising, the adoption of those methods which will make for the success of the merchant will equally make for the success of the central station.

First, therefore, it is necessary to provide a station equipped with sufficient and reliable apparatus, an adequate system of distribution, well-regulated potential, the kind of current that will meet the varying needs of those whom it is hoped to interest as customers, and a competent operating and business organization. This phase of the situation is self-evident.

Central station managers spend large sums of money in erecting fine stations, in providing efficient steam plants, in installing the best electrical machinery, in constructing high-grade aerial or conduit lines, and in maintaining well-regulated current supply.

They also spend much money for the services of consulting engineers and specialists in connection with their steam plants, their electrical plants, their buildings, and their distribution. In short, nearly every station takes the necessary and broad-gauge steps to enable it to produce electricity cheaply and to afford reliable service.

At this point, however, and after a fairly large lighting load has been secured, a very considerable number of managers of central stations have stopped to rest, and a good many of them are still resting. Notwithstanding all the very large initial expense of preparing for business, so readily assumed, officials frequently halt at the comparatively small additional expense required for the establishment of a proper department or system for marketing the very product which it has cost them so much to make available.

I am accustomed to divide the possible business which a central station may obtain into three strata, or layers. The first is the stratum which includes what may be called "spontaneous business," and such business consists of ordinary lighting and the self-evident applications of electricity,—that is, business to be secured from people who know or

feel that they can use electric service advantageously.

For instance, an owner being about to remodel his store and having seen some attractive store lighting elsewhere, determines that it would be desirable to install the electric light in his own store, and he takes the initial steps to that end.

Another case may be where a grocer has a coffee mill which, perhaps, he has operated by hand for a good many years. Somewhere he sees a coffee mill operated by an electric motor, and it occurs to him that he, too, could save time and labour by using the electric drive. Such a one takes the initiative in applying to the central station for service. Equally obvious is the case where some employee of the central station passes by a store which may be very poorly lighted, or a factory where the machinery may be but indifferently run, and where the need of better lighting may be perfectly apparent. In all such cases little or no effort is necessary to interest customers and secure a contract. This stratum yields a large amount of business, and, owing to the comparative ease of working, has been, and is, pretty thoroughly exploited.

The second stratum contains business which, while perhaps not spontaneous, is "obvious." It is of large volume and obtainable only with some considerable effort. As an illustration, the proprietor of a store has been using gas or oil for some time. The interior has become dingy and needs renovation. A representative of the central station observes that repairs are about to be undertaken, with a view of improving the premises. The proprietor may have never considered the use of electricity, or, if he has considered it, felt convinced that electric lighting would prove too expensive.

Upon being properly approached by a representative of the central station, however, who is well informed as to the possibilities of electric illumination, and who can present the subject clearly and convincingly, the merchant is readily led to consider suggestions which will enable him, perhaps, to make a very striking window display and rearrange the whole lighting of his store so as to vastly increase its attractiveness and enable him to show his goods to much better advantage than ever before.

The arguments for better air, safety from fire and freedom from danger of matches, less damage to fine merchandise, and elimination of dust and soot appeal to him, and, in a general way, recognizing the advantages of high-grade illumination, he is finally convinced that the substitution of electric light is desirable, becomes reconciled to the cost of wiring and fixtures, and is made to see that some additional expenditure for light itself may be more than compensated for by the greater attractiveness of his store and the probable increase of his sales.

A parallel case may be found in the manufacturer who is using an engine and boiler in a small shop, let us say. His business has outgrown his floor space. He dislikes to leave a location where he has achieved success and with which he has become identified. His boiler and engine are old and unreliable. The cost of repairs has become large, and break-downs are frequent. At the proper psychological moment the well-informed solicitor approaches him and shows him that by removing the antique boiler and engine he can save not only a fireman's wages, but, using floor space then made available and by installing a motor or motors on either the wall or ceiling, and perhaps rearranging his machinery, can accommodate several additional men, benches, and machines, if need be.

Here, too, we have a case in the second stratum which is developed into business for the central station with comparative ease. Such cases are but typical of many within the

experience of central station managers, and much progress has been made in developing this class of business.

The third stratum, the one most difficult to penetrate, but the one which carries the largest unrealized riches, is that which includes the great bulk of power business, and by the word "power" I include broadly all uses for current other than in ordinary lighting.

This may be designated as "latent" business, and may be illustrated, say, by the requirements of manufactories using power on a large scale, such as saw-mills, iron-working shops, laundries, grist mills, brickyards, printing establishments, pumping water supply for cities and towns, hoisting and excavating, textile works, and similar large enterprises where the opportunity for introducing the electric drive seems, at first glance, very small.

In the same stratum may be included all the novel uses for current, such as, for instance, supplying motor-generators or mercury arc rectifiers in telegraph and telephone offices, and for charging automobiles; cooking; heating; the operation of therapeutic, dental, and tonsorial apparatus; artificial refrigeration; illuminated signs; the cooling and purifying of air; the process of vacuum cleaning in houses and public buildings; the blowing of blacksmiths' forges; the application of electricity in stone yards and quarries; shoeing forges; the use of current in hospitals, bakeries, confectionery and ice cream factories; thawing water pipes; the operation of musical instruments, like the pianola, the phonograph, etc.

I presume all readers of this magazine are familiar, to a greater or less extent, with placer mining. This variety of mining is carried on in districts where the bed rock is covered with gold-bearing gravel, usually in old river or lake beds. The gravel, having been washed down from the adjacent mountains, carries gold in dust or nuggets. The process of washing out such a gravel bank is carried on by means of a contrivance known as a monitor, which consists of a nozzle firmly mounted on a universal joint so that it may be swung to and fro and up and down. When this monitor is supplied with water under very high pressure and its stream is caused to play against the gravel bank, the top of the bank is gradually swept off, and then, as the stream is lowered, little by little, the middle of the bank is dislodged, and, finally, the agglomerated or harder gravel near the bed rock.

When the stream is directed at the top of the bank, it is swept back and forth in wide arcs, a lot of ground is covered, and, as the top layers of gravel offer but little resistance, no especial attention is paid to the direction of the stream, nor is it necessary to keep it long on any one point; furthermore, the stream at this long range is rather scattered. Nevertheless, a great deal of dirt flies, and there seems to be a tremendous amount of activity going on. The result is a great deal of gravel and a little float gold and dust carried into the riffles.

As the lower levels of the bank are reached, less gravel flies, the monitor nozzle is moved through a smaller arc, and the jet, having become more solid at the shortened range, is allowed to remain longer and longer on each portion of the bank. There are more stones in this part of the bank, and it is harder; but after a time a quantity of material is dislodged and with it gold in larger particles and in greater quantity.

Finally, when the bank has been sluiced nearly down to bed rock, and the water jet, at still closer range, has become as rigid as a bar of iron, the well-trained and experienced sluicer directs the stream against the bank with all his skill,—now here, now there,—quick to see and seize every advantage, and never slacken-

ing the pressure of that resistless attack until at last the hard bedded gravel yields, and, with a crash and roar, is swept over the riffles, there to be broken up and deposit the rich buttons and nuggets of the precious metal which lie disseminated through its mass.

This last result has been achieved only by the exercise of large experience and manipulative skill and by steadily focusing the maximum power of the water on a comparatively small portion of the bank for a considerable time. There was no great amount of sand or gravel flying, and the sight may not have been as spectacular as when the upper layers of the bank were being attacked; but the result of the steady and constant drive of the powerful stream, centered at one point, finally brought away a prize well worth the effort.

So it is, in a measure, with selling electricity. The busy combination superintendent, bookkeeper, and lineman skims over the top of the bank in his town. He makes a considerable show and gets some results, but frequently he has little method in his work and does not follow it systematically. When the manager takes a hand, he is more deliberate, knows the subject a little better, perhaps, and attacks the middle of the bank. He works well and gets some business, but other matters press on his attention and he has no time to study the subject comprehensively.

It is rare that central stations have the expert talent to attack the bed rock gravel. When the man of limited experience, or one who has had no opportunity for preparation, hits it, he is frequently rebuffed and broken himself. When the man who has the experience and the opportunity for preparation takes up the work, however, he studies the situation thoroughly, decides on the line of least resistance, perfects his plans, and then makes the attack energetically, consistently, with a purpose of succeeding, and never gives up until the last effort has been expended and the last argument advanced. He usually obtains about all that he goes after.

Assuming that the central station is prepared to furnish current and has its territory well covered with distributing lines, its first move for an increase in business should be a campaign of advertising. In my judgment, no better means of achieving publicity can be employed than the local newspapers. Such newspapers circulate directly among the only people from whom a central station's clientage can be drawn; nearly every citizen reads the local paper.

Notwithstanding its many advantages and sure returns, if properly conducted, advertising in the local papers is frequently considered a necessary evil. Most central stations take a certain amount of space in the local papers for the purpose of retaining cordial relations with the publishers, although they frequently use it to little or no advantage. Well-chosen space presents enormous latent possibilities, and, having secured such space, it is well worth while to expend sufficient time and pains in preparing matter to fill it so that one's announcements will attract attention and arouse interest.

A hackneyed statement, running week after week, with no change, to the effect that "The Georgetown Light & Power Company is prepared to furnish light and power," is comparatively of little value. An effort should be made to call attention to the various uses for which electricity is valuable in a terse, interesting manner. A small space in a prominent position, if well utilized, is preferable to a larger space filled with commonplace announcements and surrounded by ordinary advertisements or "plate matter." The advertisement should not be crowded, and should deal with only one subject at a time.

In addition to the advertisement itself, short articles should be furnished occasionally, describing new

or interesting installations which the central station has made. Articles of this kind direct public attention to the various uses of electricity which are being made locally and tend to arouse interest and a spirit of emulation. Such articles are frequently very advantageous in inducing other business similar to that described, and in any event, the more people are familiarized with the use of electricity and apprised of its value in domestic and every-day affairs, the more "spontaneous" business will they offer. I regard the advantages of advertising and the efficient use of space as so important that I would recommend all central station managers to employ some capable specialist to advise and assist in preparing advertisements from time to time in case they feel themselves incompetent to do the work.

Newspaper advertising may be supplemented by the distribution of crisp, attractive printed matter, such as bulletins or flyers, consisting preferably and principally of illustrations. The object of the newspaper advertisement is primarily to bring the central station in touch with the prospective customer and arouse his curiosity or interest in the varied uses of electricity. This is about all that can be expected from such an advertisement, and it is quite enough. The function of the bulletins and flyers is not only to supplement the work of the newspaper, but to explain more in detail the service that can be rendered and enlarge on the advantages which may be obtained therefrom. They also serve to still further enlarge either the interest or curiosity of the recipient.

A record of the people to whom printed matter has been sent should be kept, and this record may well be made the basis of a "follow-up" system, for without systematic and aggressive "following up," many good prospects will be forgotten or neglected.

Next should come the solicitor, and the best results can rarely be obtained without him. It should be this man's business to call on everyone to whom printed matter has been sent, and everyone who may be regarded as a "prospect," and endeavour to increase either the interest or curiosity which they have already manifested to the point where a contract can be closed.

The solicitor must have some special aptitude for the work,—the more the better. He should be familiar with mechanical processes, general manufacturing, preferably a fair mechanic himself, and a man who is willing to devote considerable time to reading the technical papers and otherwise keeping advised of the various new and novel uses of electricity which are developed from time to time. He should be a fair judge of men, a man of good address and of good mental poise. He must be an enthusiast in his work, and he must not be tricky or unreliable. Such men are scarce, but they exist, and, further, men are constantly coming from factories and technical schools who may be trained to the work with comparative ease. It will certainly pay any operating company to train a solicitor, if the expense of securing a specialist is considered too great.

Whether the work of soliciting is entrusted to a specialist or a beginner, or even if some regular employee of the company is delegated to spend a few hours each day in soliciting, the time set apart for that purpose should never be otherwise encroached upon. If the man is not actively soliciting, he should be familiarizing himself with new and novel uses for current, or perfecting his knowledge of apparatus. He must also have time to lay out his work in a systematic and methodical manner, and make a study of customers' needs.

Again, a solicitor should never approach a prospective customer until he has first made a careful survey of the premises and the work to be

done. It is well to make an inspection of the premises where an installation is to be made prior to interviewing the proprietor. The possibilities of the situation can be much better sized up during a leisurely preliminary inspection than when in company with the prospective customer, who must necessarily receive the principal share of the solicitor's attention on such an occasion.

Again, valuable pointers may frequently be obtained from the workmen or other employees, if the proprietor is not present and the solicitor is in no great haste. All this requires time. It is advantageous to always be courteous to subordinates, for frequently they are able to indirectly, or even directly, assist a solicitor materially with information, or even influence their employer's decision.

The solicitor should sketch out a number of alternative plans for making each installation, compare them carefully, criticise each from the standpoint of the purchaser, and finally determine which plan will best meet the imposed requirements at least initial cost, insure the largest advantages, and be capable of operation at the least expense. He should then marshal the arguments in support of his proposition in due order and fix them thoroughly in his mind, so that he may be able to answer all the questions which the prospective customer will probably ask, and promptly meet objections by sound and definite statements in support of his recommendations. By so doing, the solicitor will be able to approach the customer with what we may call a dominant mind. In other words, he will know more about the whole subject than the customer does, and, therefore, be on the defensive as well as the offensive, and at a distinct advantage in discussing the proposition.

To prepare for such a campaign requires careful study and patient investigation, and a man can neither do his employer nor himself justice if his mind is distracted by the pressure of other and entirely dissimilar duties.

A solicitor should never deal in "glittering generalities." He should have his subject so well in hand that he can make definite recommendations and give definite facts. These alone are convincing.

A solicitor should never call on a customer when he is not in good bodily health and perfect mental poise. A man with a bad cold or some other bodily ailment, or a man labouring under acute nervous strain, is rarely in the best condition to exercise a dominant influence over the person to whom he is presenting his proposition. There is everything to be gained in making the first attack properly, and a solicitor should not only be in perfect condition himself when approaching the customer, but he should be tactful enough to choose an opportune time for introducing his business.

If during a visit a prospective customer shows an indisposition to discuss the matter at issue, the subject should not be pressed to a point where he becomes, in any way, annoyed. A solicitor should never allow a customer to say "No!" The moment he thinks that the customer is about to do so, he should immediately change the subject or take his departure. This leaves an opening for returning at another time. Many men, if they once decide against a proposition, will not reopen it, particularly if it does not appeal to them, but if they are never pressed to the point of refusal the solicitor may come back again and again.

One should always acquire his customer's confidence, if possible, before bringing up the main subject of the interview, and it may require several visits to do this. There is always some channel of conversation through which a prospect may be successfully approached. If he will not talk your business at once, then lead up through another subject. Nearly every man has some hobby

in which he is interested, and if one can but find out what this hobby is, he may in a reasonably short time pave the way for a better reception of his proposition than if he launches it immediately.

One can usually determine what particularly interests a prospective customer by observing his surroundings. If one sees a bag of golf clubs in a corner, he may be pretty sure that a little talk on golf will be well received. If there is a fishing rod or a rifle in evidence, an off-hand remark about hunting or fishing may make a good opening. If a roll of films is on his desk, photography may furnish a channel through which the man's attention may be secured. The subject should never be "thrown" at a prospect with nervous haste or without previous preparation. To do so is frequently to invite a rebuff and refusal to consider, which may delay further progress for weeks or months.

If the customer has radical ideas of his own in regard to what equipment he needs, he should not be immediately opposed, but be accorded attention until he has exhausted his ideas, after which the solicitor may gradually and carefully suggest changes and modifications. If the solicitor's reasons for proposed changes are sound and well-supported by facts, there is little difficulty in leading the customer to adopt them, for no man will knowingly purchase that which is inadequate for his needs or unduly expensive to install or operate. The shrewd solicitor will never assume an arbitrary attitude, nor urge a prospective customer to purchase more or larger equipment than is really necessary, but will rather coax his prospect along by suggestion and gentle persuasion, and induce him to make only such investments or contracts as will be for his real advantage.

It is very necessary that a solicitor be acquainted with the largest number of uses to which current may be applied; otherwise he will not appreciate the possibilities which are continually being presented to extend central station service.

A good collection of photographs showing typical installations of motors and other current-consuming devices is of great value in interesting a prospective customer, as well as keeping constantly in the solicitor's mind the wide range of uses for electricity. He should also keep copies and systematic notes of his work and recommendations. These, with a scrap book, in which may be preserved clippings describing and illustrating novel uses of electric service, may serve a very useful purpose.

Too many of us look for business with the physical eye only. In walking through a street in quest of opportunities for the sale of power, we are too apt to simply note the presence or absence of moving machinery or mechanical processes.

We should, however, consider the business being done in any building and then think over all the processes which must be carried on in connection with that business. From such a mental analysis we may frequently deduce a latent possibility of introducing electric service, which, if followed up, will yield a customer.

When the initial installation has been made, the work is but just begun. The customer should frequently be visited and a real interest manifested in the success of his undertaking and the satisfactory operation of the apparatus installed. Such visits are not only of great value in building up confidence in the station and its management, but make for better acquaintance and offer the best possible opportunities of introducing other uses of current or suggestions for extensions of the class of service already being rendered.

How many central station managers follow such a policy? An inspector may go the rounds occasionally, but is any high-grade man, who is capable of dealing with the matter in a comprehensive and force-

ful way, detailed to visit customers at regular periods? Half the trouble between stations and their customers might be eliminated by such methods and a vast amount of new business brought in. This is one of the most fertile fields for enlargement of business and one most neglected. Usually after the initial installation has been made, the customer is seldom or never visited save by the meter reader or the bill collector.

As a general rule, it is inadvisable for solicitors to spend too much time in elaborating on the technical side of the propositions which they present to customers. It is better to make the principal argument along the lines of general results to be secured and the ultimate advantages to be gained. As a rule, prospective customers are not so much interested in a technical description of the apparatus which it is proposed to furnish them as they are in receiving information as to its fitness for proposed use, cost of operation, or economies to be secured. A vacillating customer may frequently be led to close a contract through a visit to an existing installation similar to the one which he is contemplating. Solicitors, therefore, should keep themselves thoroughly informed as to the success which attends every installation which they make and the attitude which the owner may be expected to assume when advising a visitor in regard to the satisfaction that he has obtained from electrical service.

Among the principal arguments which the solicitor may use in interesting a customer are saving in power, space, attendance, maintenance, operating expense, production, and greater convenience, attractiveness, safety and reliability, and an effort should be made to find some argument under as many of these heads as possible which will be applicable to each case in hand.

When starting a new solicitor on his work, I think no better directions can be given him than these:—

Be honest in your representations and advice. Make your employer's business your own, and remember that the unreserved approval of satisfied customers is the best asset a public service corporation can enjoy.

Be observant of every possibility and opportunity for the use of current.

Be receptive for every new and valuable idea, every hint and every suggestion for obtaining new business or new customers.

Be enthusiastic, for enthusiasm, tempered with good judgment and joined with accurate knowledge, will surely bring success.

Be aggressive in following up every prospect, and in endeavouring to find legitimate purposes for which every customer may use more current.

Be determined that you will achieve the reputation of being the best solicitor in the business.

The next most valuable means of securing business is through a well-organized and well-equipped show-room. Such a room should be on a principal thoroughfare, on the ground floor, and, if possible, should be provided with large, low windows, in which a display of electrical appliances may be made for attracting the attention of passers-by. The size of the room and the amount of money spent in fitting it up must be determined by the prosperity of each individual company; but its establishment should be regarded as a necessity of business, and the exhibits should be as numerous and comprehensive as possible.

Within the room ought to be arranged typical lines of motors, heating appliances, illuminated signs, cooking utensils, tonsorial, dental, and therapeutic apparatus,—all connected up so that they may be shown in operation and their merits clearly explained to inquirers. There should also be at hand printed matter describing the various appliances shown and containing well-written descriptions of their respective merits. Some one should be designated

to have charge of such a show-room, and he should be fully informed of the advantages of each article shown and the approximate cost of operation, and be able to clearly and interestingly point out the advantages to be gained by its use. In my judgment, it is also very essential for central stations to keep on hand some small stock of the devices which they show, in order that immediate deliveries may be made when occasion requires.

The windows offer exceptional opportunities for attracting the attention of passers-by, and their potential value ought to be carefully utilized. It seems inadvisable to attempt large and heterogeneous displays. On the contrary, it is better to exhibit devices applicable to one particular class of work at one time, and change the exhibit frequently.

As it is the principal function of the window display to catch the eye and arrest the attention of the passer so that he will stop and survey the contents of the window, the general aim of display should be to produce a striking and definite effect. Therefore, it seems better to dress the window with an appropriate floor cover and background of some neutral-tinted material which will afford a good contrast, against which to display a few articles, with neat signs calling attention to their uses. Window exhibits are usually more attractive if shown with current on and in operation.

I believe that a very considerable liberality in installing motors, heating apparatus, signs, and similar devices on trial is fully justified. It not only shows confidence in the service which is recommended, but it also enables a prospective customer to ascertain the advantages which have been claimed without actually assuming responsibility himself. Experience has shown that the percentage of cases in which trial apparatus is removed, provided it has been recommended with good judgment, is well adapted to the requirements and has been carefully installed, is very small indeed. The expense of looping in a circuit for a few days' use, especially if the customer is to be served from overhead lines, is comparatively trivial, and the willingness on the part of the central station to make the trial always enhances the customer's confidence in ultimate results.

It is not to be forgotten that a large, well-distributed load at a moderate rate of charge is better in all respects than a small peak load at high prices, and managers should not be too conservative in making attractive rates for fear of losing income. If advantage is taken of special advertising and aggressive soliciting, at any time when rates are lowered, it is almost invariably true that more than enough additional business is secured not only to maintain the income intact, but to increase it.

I am aware that the manager of the small station will answer to my arguments,—"Your advice may be good for those stations having large incomes and many customers, but it is valueless to me. I have neither money for advertising, solicitors nor show-rooms."

My answer is that until he makes a beginning along the lines indicated, his station will always be small and his income moderate. The scale on which all these business-getting methods should be undertaken will depend wholly on local conditions. It is not my expectation that every station will at once emulate New York or Boston in these matters, but all should make a determined effort to achieve some systematic progress from year to year toward the desired end. Great merchant princes and manufacturers have fully demonstrated the value of insisting on a division of earnings whereby a portion is as religiously and definitely set aside for publicity and business-getting as for up-keep or dividends.

RECENT BRITISH LOCOMOTIVE ENGINEERING

PREVALENT CHARACTERISTICS OF ITS DEVELOPMENT

By Charles Rous-Marten

Concluded from the April Number

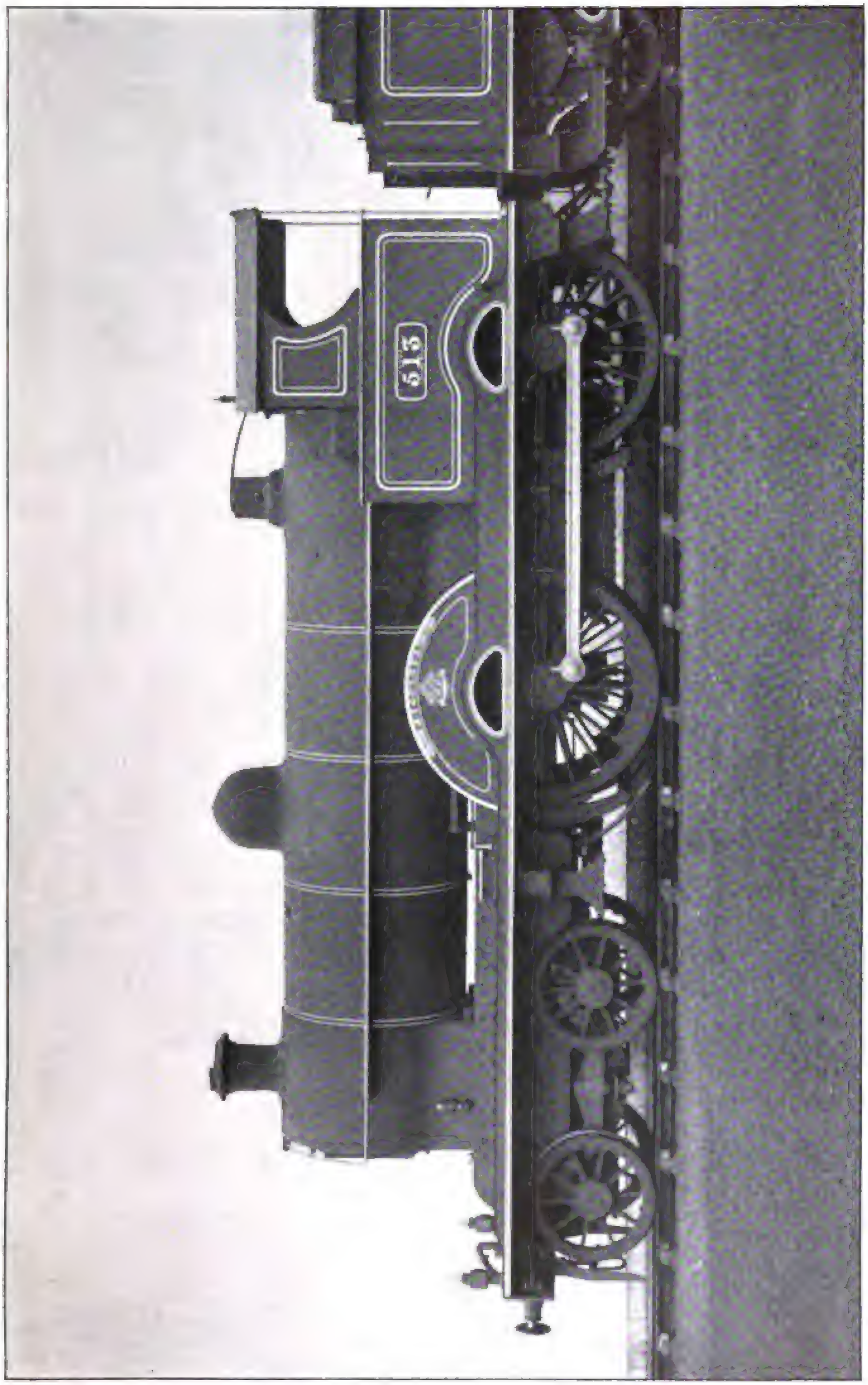
BUT while boilers have become gigantic and cylinders remain large, there has been, paradoxically as it might at first sight appear, a marked diminution in the diameter of the driving wheels. No more do we see or hear of 9-foot drivers as in 1853, or drivers of 8 feet 6 inches as in 1847, or of 8 feet as in 1846, 1862 and in 1870; or of 7 feet 9 inches as even so recently as the year 1900; or of 7-foot 7-inch coupled wheels as in 1896. At the close of the nineteenth century, 7 feet were regarded as the proper diameter for the coupled wheels of a high-speed locomotive. It was to be found on nearly every leading railway in England proper, though but rarely in Scotland.

The Great Western, it is true, had only four engines with 7-foot coupled wheels, and these were distinctly unsuccessful. The London, Brighton & South Coast, the London, Chatham & Dover, and the Great Northern had none, but the London & South Western, the South Eastern the Great Eastern, the London & North Western, the Midland, the North Eastern, the Great Central and the Lancashire & Yorkshire have them in vast numbers and treat 7 feet as the standard size.

In this year, 1906, however, we do not find any leading British railway building engines with 7-foot coupled wheels, except in the single instance of Mr. Deeley's "1000" class compounds. The Great Western uses 6-foot 8-inch wheels; the London & South Western, 6-foot 7-inch wheels; the London, Brighton & South Coast, 6 feet 7 inches and 6 feet 9 inches; the South Eastern & Chatham, 6 feet 8 inches and 6 feet 6 inches; the Great Northern, 6 feet 7 inches; the London & North Western, 6 feet 9 inches; the Midland, 6 feet 9 inches; the North Eastern, 6 feet 10 inches; the Great Central, 6 feet 9 inches; the North British, the Glasgow & South Western, and the Caledonian, all 6 feet 6 inches.

The latest Great Eastern and Lancashire & Yorkshire express engines have, it is true, 7-foot coupled wheels, but neither line has designed any new locomotives for express service very recently. These sizes quoted are, however, the largest in modern express practice. There are many others far smaller; for example, 5 feet 8 inches on the Great Western; 5 feet 6 inches and 6 feet on the London & South Western; 6 feet 3 inches on the London & North Western; 5 feet 8 inches on the Highland, and only 5 feet on the Caledonian.

It is a rudimentary fact needing no demonstration that with a given cylinder size, reduction in wheel diameter means enhanced tractive force, and enhanced tractive force is what is chiefly required of an up-to-date locomotive. When it is borne



LATEST FOUR-COUPLED EXPRESS TYPE OF THE LONDON & NORTH WESTERN RAILWAY. DRIVING WHEELS, 6 FT. 9 INS. CYLINDERS, 19 X 26 INS.

in mind that with the generally popular cylinder dimensions, 19 inches by 26 inches, a mere decrease in the driving wheel diameter from 7 feet to 6 feet 6 inches means an increase in tractive force from 111 to 120 pounds for every pound of effective pressure on the pistons, the value of this change will be realized, while in the case of Mr. McIntosh's "Oban" engines which have coupled wheels only 5 feet in diameter with their 19 by 26-inch cylinders, the tractive force is as large as 156 pounds per pound of effective cylinder pressure. When, too, it is remembered that these last-mentioned engines have ample boiler power behind their cylinders and nearly 50 tons adhesion weight on the six-coupled wheels, it will be seen how vast an increment of efficient force may be gained by a mere modification of the machinery of operation, even though the means of generation and transmission remain unaltered.

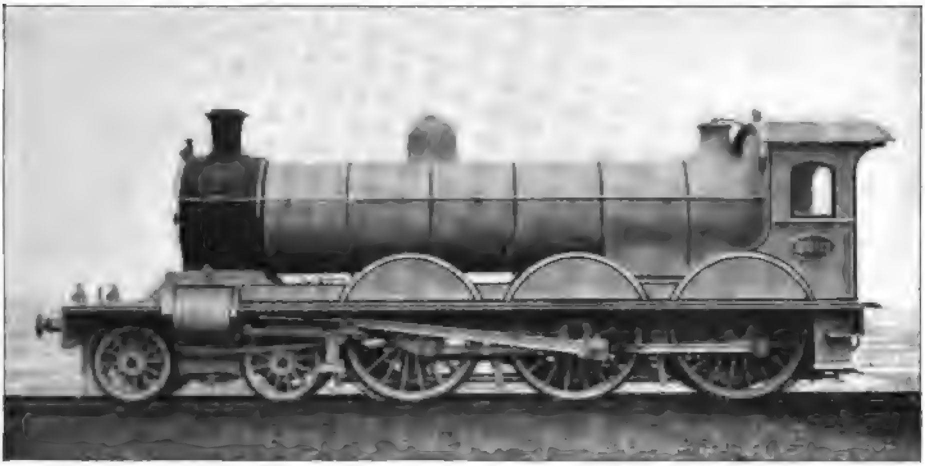
It is true that we have here a simple adaptation of the first principles in mechanics. Yet this fact can hardly have been fully appreciated, even in comparatively recent days, else it can scarcely be supposed that we should have seen so long a perpetuation of needlessly large driving wheel diameters.

It is not my intention, however, to ignore for a moment what may be urged on the other side, that is to say, in favour of the large wheels which till lately were so strongly favoured. Some of those contentions are, however, wholly untenable. Such, for instance, is the view so commonly held, and that not solely among laymen, that reduction in driving wheel diameter means loss of swiftness. This time-honoured fallacy has been demolished over and over again, yet persistently rears its head anew from time to time.

No scientific reason is ever adduced for this misplaced faith, which apparently rests solely on the fact that in the early days of railways, the Great Western, the only line that used 8-foot wheels, ran at the best speeds. It is commonly forgotten that the Great Western in those days had the largest boilers, with 1952 square feet of heating surface, and cylinders 18 by 24 inches, and also the best road and rolling stock. So soon as the standard-gauge railways levelled up to the Great Western mark in road and equipment, so they did also in speed.

When I made a special inspection of the British railways on behalf of a colonial government, in 1884 and 1885, the 7-foot gauge being still in use on the Great Western, I conducted some very careful tests as to maximum speeds, with the result that 8-foot wheel engines of the Great Western (broad gauge) and Great Northern merely "tied" with 7-foot and 6-foot 9-inch wheel engines of the Midland. In more modern days I have never found the Great Northern 8-foot single-wheelers equal in maximum speed either the 7-foot 6-inch wheel engines on the same line, or the smaller wheeled coupled engines on other railways.

I have not found the 8-foot wheelers able to reach a higher rate than 85.7 miles an hour under the most favourable conditions; that was recorded only once, and 84.9 once, the absolute maximum in all other cases being much lower with the 8-foot engines. With 7-foot 9-inch, 7-foot 8-inch, 7-foot 7-inch, 7-foot 6-inch, 7-foot, 6-foot 9-inch, 6-foot 8-inch, and 6-foot 6-inch wheels I have registered maxima of 90 to 91.8 miles an hour. The highest speed which I have ever personally recorded, or of which I have any authentic knowledge, has been 102.3 miles an hour, attained by an engine with four-coupled 6-foot 8-inch wheels on a steeply falling gradient. My second and third highest rates were reached by other engines of the same type, viz., 97.8 and 95.7 miles an hour respectively, while my fourth highest, 93.8 miles an hour, was attained by an engine with six coupled wheels only 6 feet 3 inches in diameter. All,



PERIOD OF 1900—WORSDELL'S SIX-WHEELED PASSENGER ENGINE. NORTH EASTERN RAILWAY. CYLINDERS, 20 X 26 INCHES. COUPLED WHEELS, 6 FT. 1 IN. TOTAL HEATING SURFACE, 1750 SQUARE FEET. STEAM PRESSURE, 200 LBS.

of course, were run down falling grades.

These experiences make it plain enough that large driving wheel diameter is by no means essential to high speeds. Indeed the fact has long been recognized by leading engineers. But other advantages are possessed by large wheels which cannot be so readily or decisively disposed of as the unfounded claim to superior swiftness. In the first place, with a given length of piston stroke, larger wheels necessarily permit a slower piston speed than do smaller ones. This is generally reckoned advantageous on the score of the less violent motion of the reciprocating parts and of the diminished stress of wear and tear thence accruing. Even this, however, may not be an unmixed boon, for it is held by some that a high piston speed is conducive to greater efficiency in locomotive work.

But a second argument in favour of larger driving wheels is the perfectly sound one that at a given rate of travel by the engine the cylinders are "swept" out proportionately more seldom by the piston, and that consequently less steam is consumed. This, however, merely brings us back again to an all-pervading yet oft overlooked principle in locomotive engineering,—that of compromise, of "give and take," of balancing one thing against another, one advantage against another drawback.

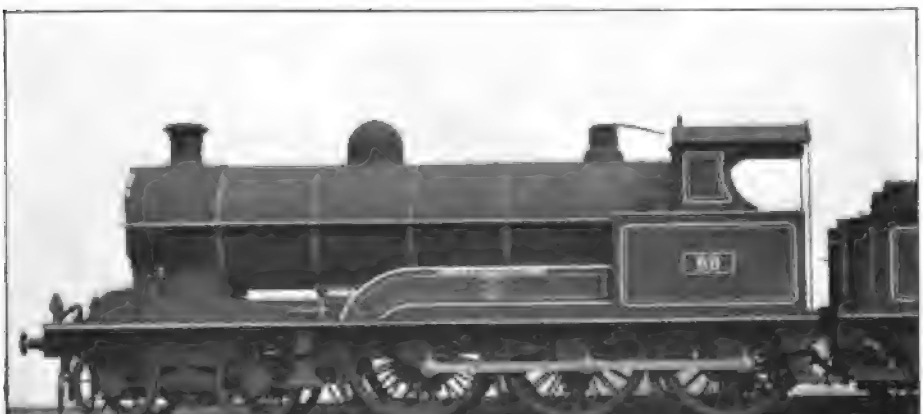
The problem has to be faced. Is it better to have larger tractive force at the cost of increased piston speed, or vice versa? Formerly the latter alternative was generally preferred. Nowadays the former finds more widespread acceptance and adoption, and this is one of the salient features in the modern developments with which I am dealing. The smaller sized driving wheel is now unhesitatingly and universally adopted.

A striking instance may be found in the case of the splendid du Bousquet-de Glehn compounds on the Nord and Paris-Orleans railways, of France. They were originally constructed with 7-foot driving wheels, but when increased speed was required as well as greater haulage power, 6-foot 8-inch wheels were adopted in the newer engines, and with these a speed of 90.2 miles an hour was attained in a special test, a kilometer being run in 24.8 seconds on a falling gradient of 1 in 200. Up a rising grade of 1 in 200, a

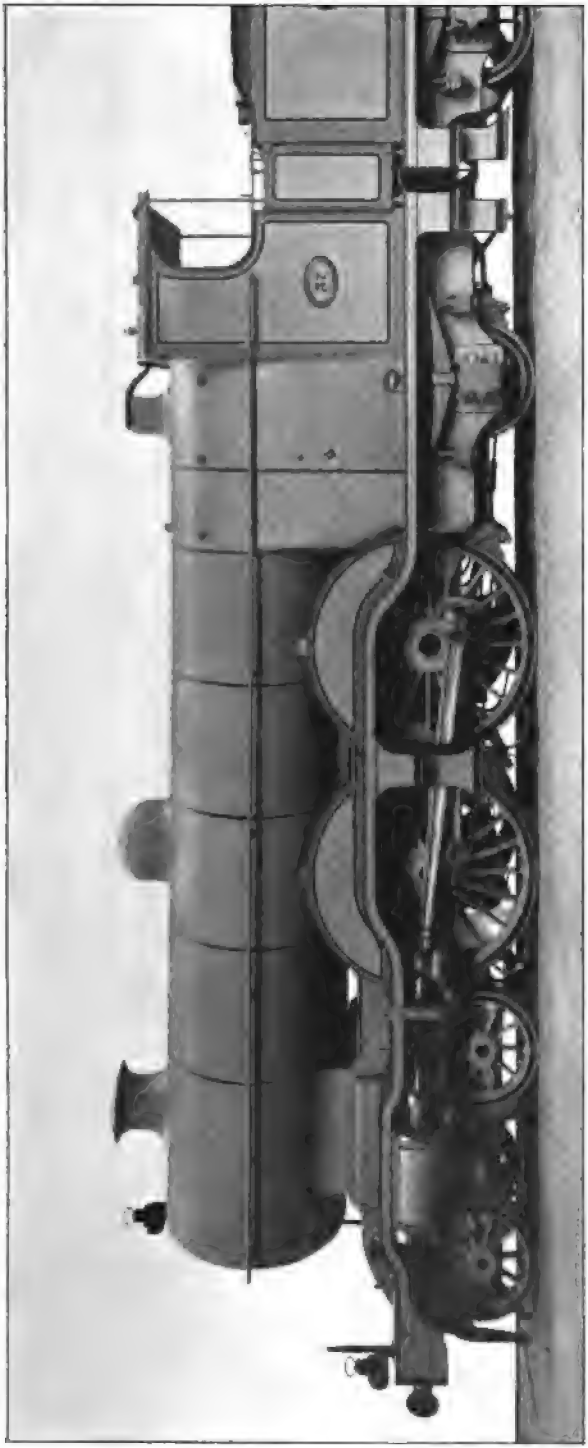
speed of 62.1 miles an hour was continuously maintained for 13 miles on end with over 300 tons behind the tender. Here we have both speed and haulage power combined, and engines of the same class are now at work on the Great Western Railway of England.

But it is not only in express passenger locomotives that the same principle has been put in practice. For fifty years nearly all goods engines in Great Britain had six coupled 5-foot wheels, some had 5-foot 6-inch, or even 6-foot wheels, four coupled. Most of the newest goods types, however, have eight wheels coupled, and their diameter is only 4 feet 3 inches to 4 feet 6 inches or 4 feet 8 inches. Alike on the Great Western, the Great Northern, the London & North Western, the North Eastern, the Great Central, the Lancashire & Yorkshire, and the Caledonian lines, these wheel diameters and eight-coupling have

THE LATEST FRENCH EXPRESS TYPE ON THE GREAT WESTERN RAILWAY. FOUR-CYLINDER BOUSQUET DE GLEHN COMPOUND. HIGH-PRESSURE CYLINDERS, 14 X 25½ INCHES. LOW-PRESSURE CYLINDERS, 23 X 25½ INCHES



LONDON & NORTH WESTERN NEW SIX-COUPLED EXPRESS TYPE. DRIVING WHEELS, 6 FT. 3 INS. CYLINDERS, 19 X 26 INS



LATEST EXPRESS TYPE ON THE LONDON, BRIGHTON & SOUTH COAST RAILWAY. DRIVING WHEEL DIAMETER, 6 FT., 7 INS. CYINDERS, 18¼ X 26 INS.

come into large and increasing use. Both have long been common on the European and American Continents, and in most of the British Colonies. Their adoption in the mother country, if belated, is assuredly judicious.

In the case of tank engines for suburban passenger traffic the same principle has also come into vogue. Among the earliest tank engines were those designed by J. V. Gooch in 1852 for the Great Eastern (then Eastern Counties) Railway. These had single drivers as much as 6 feet 6 inches in diameter. About 1853, Mr. Pearson, on the Bristol & Exeter (now Great Western) Railway, "went one better" and turned out double-ended ten-wheeled tank engines with single driving wheels 9 feet in diameter.

When tank engines for working the Metropolitan and District Underground Railways had to be designed they were given 5-foot 9-inch wheels four coupled, and when the London, Tilbury & Southend line undertook the "horsing" of its own trains it provided first 6-foot and then 6-foot 6-inch four-coupled tank engines for that service. But in the vast majority of cases the passenger tank engines had four

coupled 5-foot 6-inch wheels. Those of the London & North Western were an exception, for they had only 4-foot 6-inch wheels until F. W. Webb's later days, when he gave them successively 5-foot 6-inch wheels four-coupled, and 5-foot wheels six-coupled. More recently there has been a general outbreak of very powerful tank engines, usually with 5-foot wheels, but some with 5 feet 8 inches, and a few on the Great Western with even 6-foot 8-inch wheels for special "short express" duty, but as a rule the size is not more than 5 feet, and often smaller.

Increment of haulage power has been aimed at in another branch of modern development, viz., in the multiplication of coupled wheels. In the early days the only locomotive type deemed suitable, or even permissible, for fast running was the single-wheeler. A few four-coupled express engines were built in the fifties for the Great Western and Great Northern lines, but did not prove entirely satisfactory. In the early sixties some came in also on the South Eastern and Midland railways; later the London & South Western, and other lines followed suit, but only under protest as it were, so that when the success of Mr. Stirling's 8-foot single-wheelers on the Great Northern showed what that type could do, and the Gresham-Craven sand blast afforded a means of obviating the main drawback—excessive slipping—there was quite a rush to revive the single-wheeler, most railways resuming their construction, for example, the Great Western, the London, Brighton & South Coast, the Great Eastern, the Great Northern, the Midland, the North Eastern, the Great Eastern, the North British (2), and the Caledonian (1).

But it gradually become manifest that enough adhesion weight could not be given to enable a single-wheeler to grapple with modern loads at modern speeds, and so the reign of the coupled type has become universal. Nay, more, the latest developments point to the increasing prevalence of the "4-6-0" or six-coupled bogie type of express engine, which is now in extensive use on the Great Western, the London & North Western, the North Eastern, the Great Central, the Glasgow & South Western, the Caledonian and the Highland lines, while many more are to be built.

Here again arise the two questions of speed capacity and economy. As in the case of small and coupled wheels the feasibility of swiftness on the part of six-coupled engines has been repeatedly questioned, the fast work so often done by ordinary six-coupled goods engines with wheels only 5 feet in diameter on the Great Western, the London & North Western, and other lines, and by six-coupled engines with 5-foot 8-inch wheels on the French Nortnern Railway has been curiously ignored.

But Wilson Worsdell had the courage to build ten six-coupled engines with 6-foot wheels for the North Eastern express services, and these proved able to attain a speed of 80 miles an hour, while his second batch with 6-foot 8-inch wheels did even more than this. I myself have tested six-coupled engines on the Great Western and Great Central railways at 88.2 miles an hour; on the Caledonian and the Glasgow & South Western, as well as on the North Eastern, at 75 to 80, the running being admirably smooth. When the Great Western and the Great Central six-coupled engines were doing 88.2 they had by no means "shot their bolt," but were steadily accelerating when compelled to slack for stations or signals. This does not look like deficiency in swiftness.

The question which really arises is the same to which I have referred in the case of small versus large wheels,—Is the advantage of additional adhesion weight purchased at undue cost through the necessarily enhanced wear and tear of six as

against four coupled wheels? This can be learned only by the practical experience of actual work, but so far as I can judge at present there are no symptoms of such a result, provided the "4-6-0" engines be fairly treated and employed under suitable conditions. On the other hand, the benefit of being able to use 50 to 60 tons of adhesion weight, instead of 39 at the utmost, as in the case of four-coupled locomotives, is self-evident.

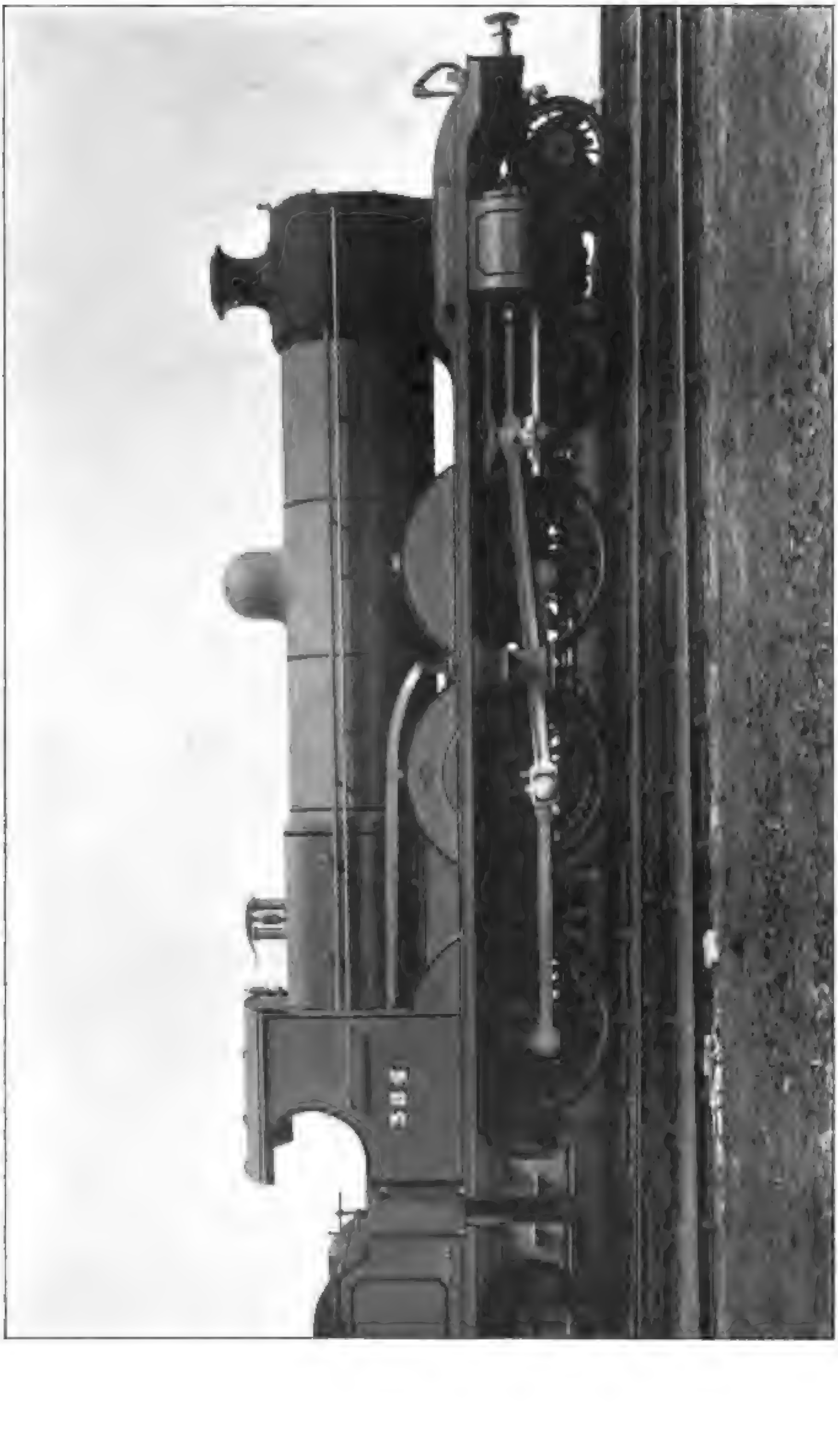
Six-coupled engines are being employed with increasing frequency in the case of passenger tank engines also. On the Great Western and Lancashire & Yorkshire a very large and heavy type with six 5-foot 8-inch coupled wheels is already fairly numerous. The London, Brighton & South Coast has many with 5-foot and 5-foot 6-inch wheels, besides the celebrated little "Terriers," which have six coupled wheels only 4 feet in diameter, and which have been virtually reproduced in large numbers by Mr. Holden on the Great Eastern. Mr. Ivatt's latest passenger tanks on the Great Northern have no fewer than eight coupled wheels with a radial trailing pair, and Mr. Holden built one tank engine for the Great Eastern which had all ten 4-foot 6-inch wheels coupled with three high-pressure cylinders 18½ by 24 inches, 3010 square feet of heating surface, 200 pounds steam pressure, and six separate safety valves.

In length of piston stroke and of cranks, there cannot be said to be any general development. Save in the two cases of the Great Western and the North Eastern, the maximum normal length of piston stroke continues what it was thirty years ago, viz., 26 inches. On the Great Western, Mr. Churchward has revived the 30-inch stroke which was tried on the North Eastern line many years back, but abandoned. Mr. Churchward employs it with outside cylinders only 18 inches in diameter, with every class of his newest engines, except only in the case of an experimental four-cylinder, non-compound "Atlantic" which he is building.

Mr. Ivatt in his four-cylinder, Great Northern non-compound uses the curiously small piston stroke of only 20 inches,—a reversion to the practice of the forties. In his large "Atlantics," too, Mr. Ivatt has adopted a stroke which is small for modern times, viz., 24 inches, combined with the very moderate cylinder diameter of 18¾ inches. The three French compounds on the Great Western Railway have a piston stroke of 25¼ inches. Elsewhere, however, the 26-inch stroke which came in almost thirty years ago on the Midland and Glasgow & South Western Railways, respectively, continues the normal standard length in Great Britain.

To sum up, the present tendency of British railways is to use engines of the "4-4-2" or "Atlantic" type for their fastest express work as the virtual successors of the once universal single-wheelers; six-coupled bogie engines of the "4-6-0" class for the heaviest express duty as successors to the six-wheeled or eight-wheeled four-coupled "2-4-0" or "4-4-0" machines previously thus employed; tank engines with six-coupled wheels and either one or two pairs of radial carrying wheels for suburban passenger traffic; a six-coupled type of tender engine with 5-foot to 6-foot wheels and leading four-wheeled bogies for "mixed" traffic; an eight-coupled type with or without a leading "pony truck" for heavy goods service. These tendencies will assuredly not lessen as time goes on and traffic increases.

It is impossible to leave my subject without a passing reference to the vexed question of locomotive compounding, but it is one of far too great magnitude and complexity to be given justice in a general article such as this,—it imperatively demands a chapter to itself. It is necessary, however, to observe that, whereas the only two systems of compounding which hitherto have



LATEST EXPRESS TYPE ON THE GLASGOW & SOUTH WESTERN RAILWAY. DRIVING WHEELS, 6 FT. 6 INS. CYLINDERS, 20 X 26 INS.

been tried in Great Britain to any great extent, viz., the Webb three-cylinder and the Worsdell-von Borries two-cylinder plans, are steadily disappearing from the London & North Western and North Eastern Railways, respectively, there seems a growing tendency to try both the de Glehn four-cylinder balanced method as exemplified by the three French engines, Nos. 102, 103, and 104 on the Great Western, and by No. 1300 on the Great Northern, and the Smith three-cylinder balanced system as in the case of No. 1619 on the North Eastern, Nos. 2631-2633, 1000 to 1009 on the Midland, and No. 258 on the Great Central Railways. Mr. Ivatt also is trying, on the Great Northern, a four-cylinder compound of his own design.

Those of Mr. Webb's four-cylinder compounds which have been reconstructed by his successor, G. Whale, with new valve gear giving separate cut off, appear likely to merit perpetuation even though their multiplication be deemed unnecessary; but, to tell the truth, compounding is still in its infancy in Great Britain which lags as far behind Europe and America in this respect as until quite recently she did in respect of large boilers, high steam pressure, increased adhesion, and booked speeds.

Another point which I have refrained from discussing in this article is the experimental employment of four cylinders in single-expansion locomotives, because that is at present in so purely tentative a stage that it would be altogether premature to class it among the regular developments of the locomotive. D. Drummond has designed and built ten for the London & South Western, but the value of the device has still to be determined by experience, which also must govern its likelihood of perpetuation. The same may be said of Mr. Ivatt's four-cylinder compound on the Great Northern. Mr. Churchward, too, is about to try the same experiment with a Great Western "Atlantic," but this is as yet wholly a matter for the future. It is gratifying, however, to note the present tendencies toward development all round in British locomotive engineering.

THE ADVANTAGES OF DIRECT-CURRENT TRANSMISSION

By Alton D. Adams

THE proposed transmission of power from Victoria Falls to the Rand, in South Africa, by means of direct current, calls attention to the advantages of this system. On long electric transmissions, even where they fall far short of the 700 miles between the great falls of the Zambesi River and Pretoria, the complete line, including both conductors and supports, becomes the largest item in the plant investment, and on the line the advantages of direct current are most marked.

At the outset of plans for a very long transmission comes the question of line voltage, and right here constant, continuous, or direct current is at an advantage over alternating current of any phase. The reason is that the effective voltage of the constant-current circuit is its maximum voltage, while the effective voltage of the alternating-current circuit is only 0.707 of its maximum voltage, if the alternating voltage follows the sine law. In other words, for equal effective voltages, the maximum voltage of a single-phase or two-phase alternating-current circuit is 1.41

times that of a constant continuous-current circuit. Even in a three-phase circuit, the maximum alternating voltage is higher by a large percentage than the voltage of a constant-current circuit for the same power and loss and weight of conductors.

Another advantage of the constant-current transmission lies in the fact that the maximum voltage is on the line only at times of full load; at other times the voltage is proportional to the load. In contrast with this, the voltage of an alternating circuit is substantially the same whatever the load.

During several years, the effective pressures of long transmissions with alternating current have halted at about 60,000 volts, and it is well understood that much higher voltages can be made practicable only by the gradual improvement of line insulators, and by the adoption of supports that allow greater distances between conductors. As maximum, rather than effective, voltages make these changes of insulation necessary, the use of constant current warrants the extension of the lengths of transmissions even with present methods of line construction, because this use allows the effective voltage to be raised.

Practice has quite generally settled on the use of three-phase circuits for long transmissions with alternating current, because this form of circuit requires only 75 per cent. as much copper as a single or a two-phase line, all other factors being the same. This saving in weight of conductors, however, is made at the expense of several other items. One-third more pins and insulators must be provided for a three-wire than for a two-wire circuit, and if the two-wire circuit carries continuous current its insulators may be of a smaller and less expensive pattern than the insulators of a three-phase circuit, where the power, loss, and effective voltage are the same for each.

Three-phase circuits at high voltages increase the size or double the number of poles or towers that would be necessary for constant-current circuits to do the same work. Where wooden poles are used to carry three-phase circuits at effective voltages of 40,000 to 50,000, or more, the general practice is to provide a line of poles for each circuit, so that one wire may be mounted at the top of each pole, and the other two wires of a circuit at opposite ends of a single cross-arm. Construction of this sort is adopted largely to obtain sufficient distance between the conductors of a circuit, without using very heavy and costly poles and cross-arms.

In circuits operated at 50,000 to 60,000 volts, it is very desirable to have the conductors as much as 6 feet apart, and poles and cross-arms of ordinary size and strength will carry only one such circuit each. Examples of such construction may be noted in the 60,000-volt, 154-mile line between the Electra power house and San Francisco; in the 50,000-volt, 83-mile line between Shawinigan Falls and Montreal; and the 50,000-volt, 65-mile line between Canon Ferry and Butte, in Montana. On the Shawinigan Falls line the three conductors of each circuit are 5 feet apart, and on the Canon Ferry line the conductors are 6½ feet apart.

It frequently happens that two circuits are wanted on a long, high-voltage transmission, and then the use of three-phase current makes two lines of poles necessary, as is the case between Canon Ferry and Butte, and between Shawinigan Falls and Montreal. With constant current on the line, the reasons that go to make two circuits desirable are in great part removed, but if a pair of circuits is still wanted, they may both be readily carried on one line of poles of substantially the same size that is necessary for a single three-phase circuit. As the constant-current circuit consists of only two wires, one cross-arm of moderate length will carry such a circuit with 6 to 8 feet between its conductors, and two cross-

arms on the same pole, one close to its top, provide for two circuits without increasing the length of the pole beyond that required for three conductors with like distance between them.

For a given weight of conductors per mile, a constant-current circuit presents a stronger construction than a three-phase, because each wire is larger by 50 per cent. in the former than in the latter. Thus, taking the sizes of B. & S. gauge, if three No. 2 wires were required in a three-phase circuit, its weight would be 606 pounds per 1000 feet, and the strength of each wire would be 1772 pounds, in annealed copper. For a constant-current circuit of two No. 0 wires the weight would be 640 pounds per 1000 feet, and the tensile strength of each wire would be 2818 pounds.

With equal effective voltages on each, the constant silent escape of energy from wire to wire of a transmission circuit through the air, is greater with three-phase than with constant current. The greater loss between the wires of the three-phase circuit is due to its higher maximum for a given effective voltage, and to the existence of three paths instead of one for current to pass through the air.

In transmission with constant current the most desirable size of conductors for a given case, and also the distance between them, may be selected without regard to inductance, which has to be reckoned with on three-phase circuits.

Some of these advantages of constant-current transmission appear to imply a considerable saving on long lines, over the cost of the three-phase system, but whether this is more than offset by disadvantages in the generating and receiving equipments remains to be determined.

THE BUSINESS DOCTOR

HIS GROWING FUNCTIONS IN ENGINEERING WORKS

By J. F. Gairns

In these days of experts and specialists it is somewhat astonishing that, so far as the writer is aware, business doctoring, to use a convenient popular phrase, has not been introduced as a recognized profession. That the introduction of the "business doctor," that is, a specialist in what may be termed the "diseases" of business, as a factor in modern business, whether purely commercial or associated with manufacture, offers great possibilities, no business man will deny, and a few remarks concerning what the writer conceives to be the scope of work for, and the probable methods of, a "business doctor" in particular reference to a manufacturing business, will probably be of interest and possibly of use, though the writer does not claim qualifications other than those of independent observation and considerable research.

In some respects a business doctor must be a jack of all trades, for his knowledge must cover a considerable range of industry, and he must be familiar with business methods and circumstances almost irrespective of the nature of the business done. He must also possess capabilities for looking on both sides of any matter brought before him, and of weighing evidence carefully before he will accept all that is told him, or is placed before him, as truth or as being absolutely correct, for it must often happen that the cause of the trouble he is called in to remedy will

be found to lie in a state of affairs that appears to persons actually concerned as entirely satisfactory, but is really the reverse. Moreover, he must be an expert in ascertaining sources of weakness or dissatisfaction that are not apparent, in many cases before matters have reached a stage of real seriousness. Further, he must be familiar with all the ordinary methods of fraud and dishonesty, and many of the special forms of roguery as well.

In addition, a really capable business doctor must be of unimpeachable character himself; he must be quite independent of influences which may bias his judgment, and if called in, whether his advice is taken in every respect or not, he must require to be told everything, or he must be capable of ascertaining how far the information given to him is incomplete or inaccurate.

Usually, too, the business doctor will be an almost unknown personage in private life; he must obtain his business connection by private recommendation, for the mere fact of his being called in by a firm as advisor may, if known generally, be deleterious to the business of a firm, and it is probable that this explains why "business doctoring" is not a recognized profession, or why the present writer has not been able to identify a business doctor if he actually exists.

I have stated that a business doctor must be somewhat of a jack of all trades, but this requires a little qualification, though the statement is correct in the main. Strictly speaking, he must be more or less familiar with most related trades or trades possessing similar departments or sections, and he must have a good groundwork of all-around knowledge, with special reference to practical aspects; but the quality which he must possess above all others must be that best described as gumption.

It may be argued that it is only a person having practical experience in, say, a machine tool business, who can properly investigate the weakness of such a business; but while this is substantially correct, it may require a person having only a general engineering knowledge, and there may be considerable advantage from the fact that in the course of his work he deals with a dozen or more other kinds of engineering businesses. If, however, he is required to deal with, say, a chemical business, he may be at a disadvantage, though not necessarily rendered incapable of doing useful service; but if asked to deal with a purely commercial business, it is only natural that he should be out of his element.

Having thus described what the writer conceives to be the qualifications of a business doctor, the principal causes which provide work for him will now be dealt with in reference particularly to a small, or comparatively small, general engineering business. It may be mentioned here that the following remarks will apply only partially, or not at all, to firms of very large size, or concerned with the manufacture of one article only, for usually in such cases matters are so well organized that the possibilities of business weakness, if proper management is maintained, are reduced to a minimum, or very considerably.

Before business can be done, it must be obtained, and therefore our remarks must be directed firstly to the "business getting" department of our imaginary firm. If we are to believe the advice given by some persons, particularly those associated with advertising agencies and the like, advertising is the principal method of securing business. This is true in large measure, but not wholly so, for the best work is often obtained by private recommendation, reputation for good work, promptitude in executing orders, reasonable, but not necessarily cheap, prices, and consideration for purchasers' requirements. Indeed, there are many

firms who hardly advertise at all, or who advertise only in such trade journals as are to be found in every office likely to be concerned with work of the kind in question.

Therefore, our specialist would first overhaul the advertising arrangements; the nature of the advertisements already employed may be a cause of the non-obtainment of orders. Some advertisements look paltry, and do not suggest good business. An arrangement with the printer and advertising manager of the journal in question, even if a few dollars extra expenditure are incurred, may be advantageous; and a little practical advice may set this matter right. It may be advantageous, too, to discontinue some advertisements, even without advertising in new ways.

A very common failing is that advertisements are prepared to attract "cheap business." As a rule, this is not satisfactory, for on such work the profit is necessarily small, or else poor work is done to make up, and if a firm obtains a reputation for such work, it follows almost inevitably that the better class of work is not obtained at all. Consequently after a time such a firm is compelled to do business with a very narrow margin of profit.

In such a case it is easier for our expert to ascertain the cause of weakness than to provide a remedy, but he may be able to act before the evil has become really serious, and in other cases a new departure, though expensive at first, may be the best remedy. Another method is to cultivate promptitude of delivery and regard for customers' actual requirements. Some firms dictate to customers and practically force them to take what "they" have to sell rather than what is actually required. However, circumstances alter cases, and for a satisfactory remedy the specialist must exercise principally his powers of common sense and general experience, for no rules will fit every case. It may be also that too much expense is incurred by advertising and obtaining publicity; and in small firms it is quite common for such expense to be credited incorrectly against the expenses of actually doing work, which therefore appears to be more profitable than it really is.

There are travellers and travellers; some men are worth a much larger salary or commission than they actually get, while others are far too well paid. One good traveller making a big salary may be worth a 30 per cent. raise, if only to give him new energy, while it may be economy to bring another traveller home and put him in the office or works at an estimated salary greater than the one for which he has been working "on the road." Others may be best dispensed with altogether, for if a business is rocky, a sentimental objection to discharging a good man may be false policy, and a dishonest man is best got rid of. Moreover, altogether one or two travellers may suffer, and it should be possible to provide for them, if they are trustworthy men.

A common complaint among travellers is that they are hampered and restricted by their principals either by price lists which place them at a disadvantage in competition with the travellers of other firms, or which hinder them from paying proper consideration to customers' requirements, especially when circumstances to be complied with differ from those usually obtaining. An example pertinent to the foregoing remark which came under the writer's notice may illustrate this.

A firm had a reputation for doing good work on ordinary lines, but a competing firm introduced a modified article as regards method of manufacture which could be made cheaper. As one article was as good as the other in use, a very slight reduction in price would have enabled the traveller in question to retain many orders, but his principal would not allow this reduction, and conse-

quently order after order was lost, short time prevailed in the works, and the staff had to be reduced. In this particular case the prices were eventually reduced by this firm in common with other firms similarly affected, but not until much good business had been lost, some of it never to be regained. In another case, for the sake of a very slight reduction in price, part of which the traveller was prepared to stand himself, orders worth hundreds of dollars a year were lost.

It is, of course, true that the traveller's is only one aspect of a case, and that there may be very good reasons for not giving him a free hand; but very often a give-and-take policy may encourage him in his work and prove to mutual advantage; and here again an opportunity is provided for the business doctor to act as arbitrator by virtue of his varied experience.

Another way in which the business-getting section may be at fault is in reference to estimating and tendering for orders, or in not making sufficient allowances for unforeseen circumstances and accidents. Sometimes it is policy to figure low, with a view to obtaining other work on which a better profit can be made, or, as has sometimes been the case, to enable the works to be kept in full operation so that other work need not be done at a loss; but such methods have the drawback that they may create a precedent which may be bad for future business. Moreover, when business is done largely by tendering for contracts, a series of tenders which are not accepted and which require a considerable amount of work in their preparation may impose a serious financial strain on a small firm. Further, a good deal of discretion is required in deciding what is worth tendering for and what should be left alone.

A few years ago a large firm which usually made their own machinery invited competition orders from firms dealing with the machinery in question; one of these latter firms, however, considered it as an attempt to obtain the use of other people's brains and experience, and stated as their reason for not competing that they were not prepared to spend a lot of money designing the machinery required, only to receive a small order, and to find afterwards that the noteworthy feature of their machinery had been incorporated in the work of the ordering firm. Whether this reasoning was correct in the example in question or not, the writer is not prepared to say, but the case provides an example of the fact that it is sometimes better to let an order go than to obtain it and to find that in reality other people obtain large benefit while the original builders get a quite inadequate return.

From the foregoing it will be seen that a competent business doctor can sometimes intervene with great advantage in the business-getting departments, his advice being based not on the fact that he knows more than his principals, for the time being, do about their own business, but that he brings to bear upon their circumstances an experience which is varied and more extensive than theirs has been.

One occasionally sees a notice in technical and trade papers that Mr. —— has accepted the position of advertising manager on the staff of Messrs. ——, and similar announcements. If one could look behind the scenes one would probably find the gentleman in question to have been retained because the firm thought that their business-getting department needed overhauling and that Mr. —— was an experienced man capable of doing this. Such an occurrence is one approximating to that of the employment of a business doctor, but it is not wholly so. In the work-executing section there are also as great, or even greater, possibilities attending the introduction of a business doctor.

In a drawing office it is expected that the draughtsmen in designing a machine will pay attention to convenience of manufacture, facility for repair, strength without undue weight of material, considerations for the conditions under which the article made is to be employed, the capabilities of ordinary workmen as distinct from specially skilled men, the machines on which the several parts are to be treated, and the use of as many standard parts as possible; but all draughtsmen are not equally capable, and unless the chief is well up to his work there is a possibility that unsatisfactory designs will be passed occasionally, and that methods may be introduced that will affect not only the work immediately in hand, but also future work.

As regards the actual work, it may be true economy to pay more in wages and get only really good men, or to supersede old or unsuitable machinery, and to introduce new or modified methods of shop management. Here, again, a business doctor has an opportunity for suggesting from his varied experience measures which will enable work to be done with greater advantage, sometimes better and at a less cost than formerly. The arrangement of works, machinery, offices, stores and the like may also provide subject matter for his services.

A common failing in a manufacturing concern is that when so many men have to do with each job, a share of the cost of manufacture is not credited to every one concerned, and that besides the men who actually work on it proper account is not made of the services of odd men, such as labourers, of boys, of the engine room staff, of work required for the up-keep of machinery and tools, and the like. To some extent this may be remedied by improved methods of charging for work and time (introduced probably at the suggestion of a business doctor), or by the appointment of different management. It may happen that no actual fault can be found with anyone, but all that is required is to modify systems and to help the principals, managers, and foremen by suggesting ways in which they themselves can carry out improvements.

In the clerical and routine departments, which are, as a rule, not directly profit-earning, a business doctor may be very useful, though as regards bookkeeping qualified accountants may serve as well.

The writer is quite aware that many arguments may be advanced against giving a business doctor the free hand that the foregoing remarks suggest he should have, and some readers may consider that for one man, however experienced, to carry out improvement in all departments is expecting something beyond human capabilities; but experience shows that, if properly backed up, even the employment of a new head of affairs often changes the state of affairs throughout a very big concern, and one man can sometimes achieve wonders in this way. A really capable business doctor, called in merely as adviser, may suggest much to the advantage of his employers for the time being, and if retained for six months or a year, for the purpose of initially carrying out his own suggestions, being answerable during that time only to the heads of the firm, may accomplish much good, especially in the case of smaller firms where the elaborate methods of a large concern cannot be carried out.

The business doctor, if given a free hand, may also be able to show that management expenses are more than the business can stand, and that salaries (very often big ones) are being paid to men whose positions may best be described as ornamental. Such men may be tolerated in government service, but an ordinary business concern may be made financially unsatisfactory by their presence. Favouritism and the claims of kinship are further causes of dissatisfaction.

A business doctor may also do good work by introducing methods tending towards binding together workmen and principals by kindred interests, and in causing a good working spirit between the several departments. Sometimes bickering between one manager and another, or the fact that the drawing office and the works are at daggers drawn, and the clerical staff is at war with both, may cause a lot of trouble.

The business doctor may prove an admirable peacemaker. The introduction of what has become known as a "welfare" department may be of great advantage in causing things to go smoothly, and it is sometimes money well spent to invest a few hundred dollars in providing decent dining and entertainment accommodation for the staff. The latter remedy has the added advantage that, if well managed, it can be made to pay for itself after a short time; but even if carried on at a loss, it has the advantages that it tends to form the employees into a body enthusiastic for the success of the firm as a whole. Such departments are fairly common in connection with large firms; there is scope for them on a smaller scale in smaller firms as well.

The writer has endeavoured to present here a variety of suggestions and to deal with many ways in which a business doctor may be very useful, but still more could be said on the subject. It is thought, however, that a good case has been made out for the introduction of men of integrity and wide experience as business doctors, to retain this convenient appellation, though it is expected that some of the remarks here presented will not meet with universal acceptance.

POWER HOUSE ECONOMIES

THE IMPORTANCE OF DETAILS OF OPERATION

By W. P. Hancock, Superintendent of the Generating Department of the Edison Illuminating Company of Boston

IN an article under the above title, in the April number of this magazine, the writer talked of supplies and their economical use, but only to a small extent. There are other items that come under this head which are important. For instance, if you are operating a large boiler plant, you will have in use an outfit of fire tools which, if not properly used and properly repaired, will cost a lot of money in the course of the year.

Perhaps you have made the common error of not having a sufficient number of each kind on hand to admit of having others repaired without excessive cost, that is to say, without getting so short that you have to have some one work outside of regular hours in order to have repairs made in time to prevent inconvenience. If that is the case, you will find that it will pay to have a larger supply so that no extra cost will occur for the reasons intimated.

Further, these tools should not receive hard usage. A fireman can, if careless enough, use the tools till they become overheated and consequently burned. If, however, you have extra ones at hand, and the fireman has been "brought up" right, he will change them at proper intervals, and save a lot of renewals of "ends,"—small affair to speak of, I admit, but all of these small costs help to swell the total.

How about the packing, gaskets for various uses, and the supply of small accessories that ought always to be close at hand for cases of emergency?

Before we speak of these, let me ask if you have got a suitable place in which to keep these supplies? I mean a small space which is light, and has shelves and other conveniences, so that each item may have its own particular place, and thereby make it possible for your engineers and repair men to go to that place in a hurry and be practically certain before they arrive just where some desired article will be found, and thereby, in cases of emergency, save time, patience and reputation for the company, all of which mean saving of money.

Have you gone into the question of packing with reference to what will best suit your own conditions on the steam and water ends of the steam units and auxiliaries? The packing is much like the oil talked of in the previous article, for every manufacturer has "the best," and some of them will tell you so before they make a single inquiry as to what steam pressure you are using, or whether or not you use superheat. There is only one method to pursue in the matter of this material, and that is the "cut and try" scheme.

We must not lose sight of the fact for one moment that we have to manufacture power at a cost that will show a fair return on the capital invested, and in order to reach

that point we have to do something more than to take it for granted that what the salesman says is correct. Also, we cannot afford to let new ideas in the line of accessories go by without a thought, and that for more than one reason.

First, we have the different firms who sell the goods represented by their salesmen, and they have certain rights which should be respected with reference to the claims which they make for their goods. I say they "have rights," and by that I mean that if all engineers and operators said,—without good reason,—tnat what they were using was all right, and that they did not want to try anything else of that nature, then the tendency toward improvement in the line of goods would be checked. Therefore, we cannot at all times say to the salesman, "We don't need the goods," and proceed to put him off with scant courtesy.

The other side of the question is shown when the over-zealous man comes along and wants to sell you some of "his line," which you have previously tried thoroughly and found "wanting." This salesman does not take your word as final when you tell him you have tried his goods and they do not suit. He immediately tries to convince you by exhibiting a list containing the names of many of the large companies everywhere who are using his goods, and simply ignores the fact that you had previously told him explicitly what your conditions were, and had given him a chance to sell you the right kind of material. That is the man that you cannot afford to spend time with, because he wants to sell the goods, whether you benefit or not.

Ordinarily the salesmen go to the purchasing agent, and not infrequently that officer refers them to the man who uses the line of goods in question, which is eminently proper; for in the matter of such details it is not fair to assume that the purchasing agent knows what will suit the conditions as well as does the one who handles the apparatus and watches the results day by day.

The handling of the small accessories should be done by some person or persons responsible, wno will see to it that the space reserved for the purpose is kept in order, so that any special thing may be reached quickly; and it is very necessary that when, through an emergency, one or more items have been drawn from the reserve, these should be replaced without delay, so as to be ready for the "next time" when something may be wanted in a hurry.

How is the steam and electrical apparatus cared for? One way of finding out is to wait until the end of the month, at which time the cost charges come to you, and then you wonder why the cost is so great.

Another way, very different, not in cost, but in results, is to begin in front of the fires and follow the system to the point where the trunk lines and feeders leave the power house.

Some men will answer to the above substantially as follows:—"That is all very well to talk of on paper, but it costs money; and money that goes for the pay-roll is gone in a way that does not look as satisfactory as if it had been spent for, say, coal." Is this true?

How far have you gone into this matter to find out by actual test, and to satisfy yourself personally about the profit or loss incurred by reason of using labour enough to keep the apparatus in the best operating condition?

No doubt you weigh the coal: you are very particular to know that you get the amount you pay for, and to know how much you have to consume per kilowatt-hour. But how about the boilers? Have you got enough men in the fire room to keep the fires clean, along with the other work? Do you have to use boiler feed-water that will scale up the boilers rapidly, and if so, are you

doing anything to prevent this? Perhaps no person can tell accurately what the loss in heat units is, because of scale. But if it is possible to use solvents which will keep the boilers clean all of the time, at a reasonable price, and without detriment to lubrication, valves, glands, gaskets, or other packing, and with a very small cost for labour, why is it not the thing to do? Having tried mechanical cleaning of many kinds, I am satisfied to use the other method.

You may have had to open a joint on the main steam line, or on smaller lines, for the purpose of placing a new gasket, and if so, you perhaps destroyed a portion of the pipe covering. What are you going to do about that? Surely you will admit that the very appearance of such a thing is bad. But is that all? You covered the pipe for a purpose, and a worthy one. Are you now going to let that ragged place remain as it is, and thereby defeat, in part, the object for which you covered the line when you put it up? Do not delay; cover the pipe; keep some paint in the ash room for such work as this, and have the man who is on the repairs use it; make that job testify to your intention to do these things at once when they require doing, and to do them well.

How are you keeping posted as to the steam units and gauges? Do you know how they are loaded with reference to proportions of total load in the different cylinders, and are all your steam instruments tested regularly? Do you know how the engines are loaded with reference to the head ends and crank ends? How often do you indicate them? How often do you open up cylinders on your units?

Don't you think it pays to open them often enough to enable you to have absolute assurance of the conditions inside?

Once every month reciprocating engine can be tested to a degree, and experience teaches that the cost of the work is money well expended. Here is a table of the data which it is desirable to obtain:—

Date of test.
Load kilowatts.
Horse-power high-pressure crank end.
Horse-power high-pressure head end.
Horse-power low-pressure crank end.
Horse-power low-pressure head end.
Total I. H. P.
Distribution I. H. P. high-pressure crank end, per cent.
Distribution I. H. P. high-pressure head end, per cent.
Distribution I. H. P. high-pressure engine, per cent.
Distribution I. H. P. low-pressure crank end, per cent.
Distribution I. H. P. low-pressure head end, per cent.
Distribution I. H. P. low-pressure engine, per cent.
Unit efficiency.
Steam pressure at throttle.
Steam pressure low-pressure engine.
R. P. M.

Once every month find out how the steam turbines are working. Test results can be made out as follows:—

Date of test.
Duration of test.
Load kilowatts.
Water total.
Water per K. W. H.
Water per K. W. H. corrected saturated steam, 28-inch vacuum and 30-inch barometer.
Steam pressure.
Steam temperature.
Superheat.
Barometer (inches of mercury).
Vacuum (inches of mercury).

There is no doubt that it pays to go into these matters. If more elaborate tests are necessary, these can be carried out to a degree dependent on what information is needed.

The care of the auxiliaries is important, and to keep this apparatus in proper working order will require labour and material of first-class kinds.

It certainly will not pay to undertake to operate this class of apparatus with a cheap grade of labour, and I feel very sure that whoever has tried to do so for any considerable length of time will be willing to testify that he has come to grief. To operate such important machines as modern power-house auxiliaries are, with men who have not had experience, and who, if they have had experience, do not take proper interest in their work, tends to produce a heavy cost for repairs,

and probably an interruption of service.

Of course, the construction of different power houses will show in each case what the best method is of caring for the auxiliary apparatus; but I believe that it is best, where possible, to have this apparatus under the immediate charge of a fairly high-priced grade of labour, rather than to assume that an oiler who is working on a large unit can keep an eye on the pumps as well as not, and still maintain as good operation as by the other method. I have tried both ways, and have no doubt of the results.

The care of the electric units is a most important matter, especially if the power house is operating at nearly its capacity all of the time, and possibly at a certain percentage over the rating on the peak. This being the case, heavy duty is required in the darker portion of the year, and the actual amount of cleaning necessary cannot be performed, because of lack of opportunity.

It follows, then, that thorough work in that line must be done as soon as there is an opportunity; and consequently as soon as the lighter months come along, and a unit can be spared from the peak load, every portion of the unit should be gone over with some cleansing agent, such as naphtha, for instance. The connections that are in sight should be taken down, cleaned, and any oxide which may have accumulated should be removed. This should be done with every unit in the system until the whole is complete and you feel confident that all machines are in good shape for duty.

The switches and other apparatus, and especially oil switches, need the most careful looking after. The contacts should be good, and the oil clean. The bolts on the connections should be tried, for the difference in temperature, due to changes of air in operating rooms, and the loads to which the heavy connections are at times subjected, will tend to slack bolted joints. As a result, heat will appear at the points mentioned if the precautions mentioned are not taken.

And about the instruments. Do you know whether or not they are giving you correct results as to kilowatt output? How often do you test and standardize this important apparatus?

Have you in times past found a lot of figures in making up weekly or monthly costs which showed the costs of operation to be much too high, or much too low, for that matter?

If you have had that experience, then you realized the importance of having that matter corrected, not only for the occasion, but you undoubtedly devised a method by which, at certain stated periods, all of the instruments, showing volts, amperes, or watts, would be tried, and, if found incorrect, would be made accurate.

Why is it not better to do these things right, and do the work often enough to keep the records correct, rather than find out suddenly that two or three instruments, through inaccuracy, have caused errors that will necessitate going back over the books for the past six months?

This work ought to be done, and if you have not facilities for doing it within your own organization, there are plenty of concerns that will do it for you. You will make a paying investment when you place an order for the purpose of having assurance that your records are correct.

Finally, a word about the general appearance of the buildings, inside and out, and the grounds, if there happens to be a margin of such around the property. The effect of keeping a power house clean inside has, in my opinion, an effect on help that is worth money to the company. The men whom we employ in power house work have to be men of intelligence, and to ask them to work in a foul-smelling atmosphere, with grease and dirt everywhere, is to make them dread the day ahead. A

few rules ought to be laid down which, condensed into few words, mean,—"We want this property kept clean; we will spend some money to do our part, and you have got to do yours."

My experience is, that a set of men operating or working under such conditions know what is expected, and cannot help seeing that it is right for all concerned, and that in a very short space of time the "cleanliness" of the power house becomes with these men a matter of personal pride as well as that of duty.

Don't you suppose the officers and stockholders are pleased with such appearances? Don't you believe that your prospective customer, taken, perhaps, by your agent, to show where you generate energy, would be influenced in your favour to a greater extent if he was shown a power house clean and orderly inside and out, than he would, if it were slovenly, showing a lack of system, and an appearance which conveyed to him that, "if anything happened, it would take a long time to straighten things out?"

If you have tried the slack way of doing things in this line, then try the systematic way and see the difference.

Following the details, and following them closely all of the time, is a part of the price to be paid, if you would obtain the lowest cost possible for the production of a kilowatt-hour.

Current Topics

The campaign of the metric system advocates, as at present conducted in America in connection with the iniquitous Littauer compulsory metric bill is, in many respects, one of perversion of facts,—a regrettable reflection on the ways and means of the metric man to compel attention. One instance of many is afforded by the wider impression which it is sought to create that the several electric industries are pro-metric. So insistently has this statement been made that many other wise well-informed persons have blindly accepted it as fact, when really it has been hitherto comparatively harmless fiction. But it is time that the truth be told and hammered home. None of the representative builders of electric machinery in either Great Britain or America use the metric system in their shops. Generators, and motors and all the manifold details connected with electric plant equipment are built on the English system of units. The workshop of the electric manufacturer, like the shop of the machine tool builder, or of the boiler maker, the ship-

builder or the railway, works with the foot rule, not the metric scale. As one of the largest electrical instrument makers puts it, "to use the metric system in our mechanical work, would involve us in almost inextricable confusion and annoyance." If it pleases the pure scientist and the laboratory worker to avail themselves of the foreign system, there is none to hinder them; but it is foolishness to accept them as opponents of the manufacturing end, where the problem is to turn out machinery that will do work and make money.

In the case of one single firm, in England, by the way, who tried the metric system, it is said that during the first year of its introduction they swore by it; in the years following they swore at it. And this latter would be done by every producer of things into the making of which measurements enter; and not only by the producer, but by the user, too, whose repair parts for many more years to come than can now be safely even guessed at, would be things of nerve-racking confusion. In Great Britain the Decimal Association, sailing under false colours, not considering it wise apparently to openly proclaim itself metric, is covertly working towards the metric goal; but opposition to its aims, like the opposition in America to the Littauer bill, is vigorously made by the country's foremost and most important industries, including the electric ones. And it is to be hoped that the metric ghost will be laid by it for many years. Elsewhere in this issue is presented an admirable exposé of the metric fallacy by Mr. Frederick A. Halsey, who, together with Mr. S. S. Dale, has rendered splendid service to the anti-metric cause,—the cause of common sense, we should call it,—by argument in speech and print. We commend it to careful reading, particularly to those not yet fully convinced of the righteousness of anti-metric feeling. It is not new; it has been previously published and widely circulated; but in its still wider circulation we are glad to be able to aid, all to the end of defeating a measure which has no rational reason for existence in British and American shops. Added to Mr. Halsey's paper we print supporting opinions from a number of the foremost engineers and manufacturers, with others, both British and American, still coming in, for publication in a later issue.

One of the things of which all advocates of the use of the metric system fail to appreciate the importance is that it is relatively easy to introduce any new system of units, but almost impossible to wipe out the old ones. Bringing in the metric units would simply saddle the English-speaking world with an additional system; the present one would remain. There is every needed evidence to prove this. The transition period, if it might so be termed, would be an all but permanent one. The complications which it would entail are incalculable, and the money cost of the readjustments would be far beyond their value, admitting, for the sake of argument, that this is not mythical. Something like twenty-five years ago, to quote from an earlier issue of this magazine, in a report on the subject, made to the Franklin Institute of Philadelphia, by Dr. Coleman Sellers and the late William P. Tatham, it was stated that, according to calculation, in a well-regulated machine shop, thoroughly prepared for doing miscellaneous work, employing 250 workmen, the cost of a new outfit, adapted to new measures, would not be less than £30,000, or £120 per man. If new weights and measures were to be adopted, all the scale beams in present use would have to be regraduated and readjusted; the thousands of tons of brass weights,

the myriads of gallon, quart and pint measures, and of bushels, half bushels and peck measures, and every measuring rule and rod of every description throughout the land, would have to be thrown aside, and others, which the common mind cannot estimate, substituted. The great mass of English technical literature would become almost useless, and would have to be translated from a language which we, and the nation we have most to do with, understand perfectly, into a new tongue, which is strange to most of our people. As a question of cost, let those who advocate this change consider it carefully. To the teacher, to the closet scholar, to the professional man, to those who never handled a rule or a measure, but use weights and measures only in calculation, it may seem merely a matter of legal enactment; but to the worker, the dealers in the market places, to those who produce the wealth and prosperity of the land, the question is a most serious one. Those who choose to do so can use the metric system, and no one can object to it; but, for the government to require its people to use that, and no other, would be an arbitrary measure which they would be neither willing nor able to bear.

In connection with the article on the exploitation of an invention, printed elsewhere in this issue, the author, Mr. George Wetmore Colles, has made the point that the patent system of America can properly claim credit for a greater portion of the country's industrial wealth than any other statute, or class of statutes, ever enacted,—possibly than all others put together. The protective tariff system as a stimulus to industry cannot be compared with it. Vast sums of money in actual cases have been reaped from patents since the first institution of the patent system, and other sums, constituting a very large portion of the entire capitalization of all manufacturing enterprises, are based upon patents for inventions. In fact, it might be said that no new manufacturing enterprise of any importance is started to-day without being protected by patents. As an institution of law, it is certainly more profitable, both for the government that grants, and the inventor and his allies that receive, than any protective tariff system can be; for it is automatic in its action, just in its distribution of favours, and definitely limited in its duration. The inventor and his assigns receive, for a definite period of time, the monopoly of his invention, to use as they please; and at the end of that time the possession of the invention and all the advantages and business that have sprung from it revert to the general public.

Chemical analysis is a subject of growing importance in industries which involve the purchase of large quantities of material based on definite specifications as to composition. Electric railways fall well within this generalization. Many roads, especially among the larger systems, are heavy consumers of trade products, and when these products are bought on exact requisitions, it becomes of great importance to determine the quality of material purchased. In fact, it is essential at all times to keep well posted as to the physical and chemical properties of the materials used in operation, so that the best proportions and characteristics can be specified for each particular class of service. There is scarcely a limit to the materials which can profitably be analyzed for electric railway purposes. Insulating compounds and wire coverings, paints, varnishes, rails, babbitt metal, tool steel, oils, cement, boiler compounds, coal, iron, steel, overhead material, acids, putty, brass, and many other things are constantly used in quanti-

ties by electric railways, and the composition of each must be known if intelligent selection of equipment is to be made. Information of this character is naturally of greater use to the purchasing department than to any other branch of the service, but if the records are well kept, the engineers who write the specifications are also greatly aided. Frequently the establishment of a chemical laboratory by a large street railway system, at a moderate cost, and a correspondingly modest operating expense, is the means of saving large sums of money every year. The determination of the calorific power of the coal supplied and the payment on the basis of heat units, are a logical and growing practice among large consumers. Sometimes a company can specify its own mixtures in alloys and save considerable sums each year over the prices charged for specially branded products. Of course, a small company cannot so well afford to establish a chemical laboratory as can a large organization, but there is good sense in joining issues by dividing the cost of analyses among a group of small companies in any given territory. The matter is certainly worth looking into.

A VERY simple and efficient method of determining the points on an electric railway line that are especially vulnerable to lightning, has been devised by Mr. H. H. Adams, of the United Railway & Electric Company, of Baltimore. As told in the "Street Railway Journal," he keeps in his office a large-scale map of the system, and whenever a car crew reports that a car has been damaged by lightning, he sticks a pin in the map at the point where the car was at the time. It is astonishing how quickly a record of this kind will show up the locations that seem to be especially susceptible to lightning discharges. In the course of the season a few points will have a miniature forest of pins grouped around them, while long stretches of track will show no pins at all. When a particular location begins to accumulate a collection of these telltale pins, a lightning arrester can be installed at this point and the trouble at once eliminated, or at least materially reduced. From graphic records kept in this way over a period of years, it has been determined that the most vulnerable points are at junctions of lines and at sharp bends and curves.

THE lamentable lack of employment which, during the last year or two has prevailed at Munich, has brought about the formation of a municipal insurance against unemployment, the corporation having decided to contribute an annual grant of 35,000 marks for three years. The insurance is on the Geneva system, which seems to find admirers in several countries. In Munich, according to "Engineering," a municipal unemployment fund has been formed under the management of a municipal committee, which is elected by the corporation, and consists of twenty members, ten of whom belong to workmen's associations. The fund contributes partly to the unemployment funds of the trade unions, and partly to non-organized labourers out of work, and who for some time have paid their weekly contributions to the municipal fund. Those unemployed through strikes, lock-outs, illness, or incapacity to work, are excluded from help, and, in order to obtain aid, the applicant must have resided at least one year in Munich, and either be a native or have been naturalized. The help given must not exceed one mark per day, and not last more than three weeks. An important branch in the work of the new institution is the department which finds work for the applicants, which work the latter are bound to accept, or they forfeit all assistance. There is every likelihood of other towns in Germany following

the example of Munich, the more so as the system for some three or four years has worked satisfactorily in about a dozen Belgian towns.

WITHIN the last decade many notable improvements have been effected in railway transportation. Locomotives have grown more powerful, cars more luxurious, rails heavier, block signals more numerous, freight schedules faster and long-distance passenger runs shorter in time consumed. The standards of equipment have been raised all along the line, and on progressive roads through service has, in general, been made better in point of speed, comfort, and safety. On many roads local service has made little progress, however, and suburban traffic still awaits the accelerating stimulus of electricity before falling into line with the latest advances in transportation methods. Along with these significant improvements in rolling stock and roadbed has come the construction of enormous terminal stations, but while these vast structures and their approaches represent, in most cases, extraordinary skill in design, experience has shown that in some instances there is considerable room for improvement in the methods of handling traffic under adverse conditions of weather.

IN the case of a great terminal station handling under normal conditions seven or eight hundred trains a day, it frequently happens that a thick fog or a heavy snowstorm will literally paralyze the traffic, whereas with good weather the intricate interlocking switches, signals, and train schedules operate with the precision of a chronometer. Sometimes a slight delay to a through train two or three hundred miles away from the terminal will cause a disturbance all out of proportion to the reasonable effect of the slow-down, because the arrival of a single train two, three or ten minutes off schedule in the morning or evening rush hours upsets the whole sequence of inward and outward movements upon intersecting or fouling tracks. The fact is, a modern terminal station without loop tracks for suburban service, but with a complex system of cross-overs and spurs, is an exceedingly delicate piece of machinery. In many snowstorms it seems to be impossible to keep the yard switches open, even with hundreds of men at the broom and shovel, so that it is by no means uncommon for trains to be unable to enter or leave the station, although they may traverse the more exposed tracks in the suburban and country regions with comparatively little difficulty, except from the point of view of the fireman.

IT is probable that troubles of this nature cannot be eliminated as long as terminals have to be designed to accommodate many train movements in limited time and restricted area, but it is certain that a wider use of loop tracks and a less frequent use of intersecting cross-overs in handling trains at terminals will do much to reduce the present delays, which so often grow out of seemingly small causes. As electric motors supersede steam locomotives in heavy terminal work, the obscuration of signals by vapors will be much less in evidence, and the better acceleration of the former machines will certainly be helpful in relieving congestion. The great terminal station has come to stay, but its maximum usefulness can be attained only by a careful study of recent experience with a view toward reducing the influences of unfavourable weather conditions.

IT is to the older countries of the world, especially Great Britain and

Germany, that we must turn for examples of gas works engineering on a great scale. In a recent lecture on some modern problems in gas engineering, delivered at the University of Wisconsin, Mr. Fred. B. Wheeler, of the Semet-Solvay Company, of Syracuse, N. Y., pointed out that in America, outside of the large cities, there are few noteworthy gas engineering achievements. Dessau, Germany, has a noteworthy record. Here was installed the first retort setting fired with producer gas, thirty years ago. Here was installed the first electric station run by gas engines, twenty years ago. Here was installed, too, the first tramway with gas locomotives, ten years ago, and now there are being installed the first successful vertical gas retorts. Magdeburg, Germany, first made a very low candle-power gas of high heat units, and distributed it to the whole city, using Welsbach mantels,—abolishing completely open-flame burners. Vienna and Berlin have taught the world how to construct inclines. Brussels has shown us marvels in residual recovery, and in Great Britain we have a blaze of gigantic installation of the greatest feats of engineering, Sheffield leading the world with cheap gas. The high-pressure distribution of gas through large cities, and to centres of population in outlying towns, which would otherwise have either to go without gas or suffer a higher price by the operation of a separate works, occupies a commanding position in the minds of all gas engineers, as well as the thoughtful attention of investing capitalists.

HOLBROOK FITZ JOHN PORTER

A BIOGRAPHICAL SKETCH

By Fred W. Taylor

FACTORY welfare engineering, or, perhaps better put, industrial betterment, is the work to which Mr. Holbrook Fitz John Porter is devoting himself, an active professional career of about twenty-five years having fitted him exceptionally well for this unique and rapidly growing field of endeavour.

Mr. Porter, whose father was the late General Fitz John Porter, was born in the city of New York in 1858. He was prepared for college at St. Paul's School, at Concord, N. H., and graduated from Lehigh University as mechanical engineer in 1878. His practical education then began in the Delamater Iron Works, in New York City, where he spent four years successively in the pattern shop, the foundry, the machine shop, and the draughting room, and this shop experience, in close touch with the workingmen, gave him a knowledge of their feelings and viewpoint which has proved of great value to him throughout his engineering career. The sympathy which he at that time acquired for the actual mechanics who do the work in our shops doubtless had a great influence in causing him, at this later date, to become the champion of the system of management which he now advocates, in which consideration and kindness are shown to employees, and in which, as a consequence, the workmen reciprocate by working more faithfully and permanently than they would for one less solicitous of their welfare.

As a part of Mr. Porter's practical experience while at the Delamater Iron Works he, with two other men, superintended the installation of marine engines into a vessel which was being built at the works of John Roach, at Chester, Pa. After obtaining his experience as workman and designer at the Delamater Works, he widened his engineering viewpoint by accepting a position as assistant engineer in the rolling mills of Cooper, Hewitt & Co., at Trenton, N. J.

At the time that Columbia University took up its abode at Forty-ninth Street and Madison Avenue, in New York City, Mr. Porter completed the centralization of the power plant together with the development of the heating and ventilating systems. At that time electric lighting was in its infancy, and this work of Mr. Porter was among the pioneer installations. The plant consisted of two Edison 100-light dynamos, and was looked upon as a very large plant. In this work Mr. Porter met with such success that the University position of superintendent of buildings and grounds was established, and he was made its first incumbent. He then inaugurated the system which has since continued and been developed for repairing and maintaining all of the buildings, furniture and fixtures of the University. He also designed the building for the electrical engineering department, and included in it the repair plant of the institution, consisting of machine shop, plumbing department, carpenter shop, paint shop, and upholstering shop, which served its purpose until the University moved to its present site, on Morningside Heights, in New York City, where similar accommodations were provided for these appurtenances.

Having completed his work as an organizer at Columbia University, he accepted the position of engineer and superintendent of the spring and wire mill of Cary & Moen, in New York City, in the spring of 1890, and after an investigation into the best industrial cost systems at that time in use in this country, he introduced a modern accounting system into these works, which enabled them to know accurately and quickly the cost of their product.

During the following year he was offered the position of assistant mechanical engineer at the World's Columbian Exhibition at Chicago. In this capacity he designed and installed the power plant which furnished light, power, and water for fire protection to the buildings and grounds during the period of construction, and later he was transferred to the Machinery Department, where, acting as Assistant Chief, he was largely responsible for the installation of the exhibits in Machinery Hall.

Mr. Porter's next work was that of consulting and contracting engineer in Chicago, where he installed several street railway and electric lighting plants. About that time the Bethlehem Iron Company completed their new large steel plant for the manufacture of armour plate and guns, and, being desirous of entering the commercial field with other forgings, engaged Mr. Porter to represent them throughout the West. In this work Mr. Porter was a pioneer in educating the Western manufacturers and steamship owners away from the use of the older type of wrought iron forgings and into an understanding of the value of high-grade steel forgings.

Mr. Porter possesses uncommon ability as a lecturer. He has the happy faculty of presenting his subject in a most entertaining and convincing way to his audience, and his numerous lectures upon the uses of high-class steel, delivered not only before technical societies, but also before many of the classes in Western universities, are still remembered as most interesting and instructive. He was convincing in his arguments for the use of hollow-forged steel engine shafts in power plants, pump-

ing stations, street railway plants, etc., and such shafts are now used in many of the largest installations in existence. He was a pioneer in introducing nickel-steel forgings for steam railway service, and while in the employ of the Bethlehem Steel Company was called upon repeatedly to lecture before engineering schools and scientific societies upon that then new metal.

In 1902, when the Bethlehem Steel Company was merged into the United States Shipbuilding Company, Mr. Porter accepted a call from Mr. Westinghouse to manage the American branch of the publishing department of the various Westinghouse companies at Pittsburg. His success in this department led to an offer from Mr. Westinghouse to Mr. Porter to become second vice-president of the Nernst Lamp Company, in which capacity he acted as general manager of the affairs of this company.

Through his ability as an organizer, within six months after he took charge the details of the lamp had been so far perfected that its standing in the electric lighting field was changed to its present high rank among the electric illuminants. His success with this company was the result of the effective introduction of his ideas regarding the hearty co-operation between employer and employee, and when he finally left it not only were the results of his services to the management most gratifying, but his loss was personally deplored by the whole force of employees.

The practical experience which he obtained there in the introduction of his system of management led him to become a firm believer in the commercial value of the interested service of employees, and accordingly he opened an office in New York City for consulting practice, aiming to install modern methods of organization and management. His own success and personal experience in this field have led him to lean toward industrial betterment, and he is prepared to demonstrate that enlightened treatment of the employees which involves developing their abilities and increasing their loyalty pays, not only because it is morally right, but because it yields a large return in dollars and cents.

It is interesting to note how many companies are now leaning in this direction. Many employers, however, who realize the importance of this element in management do not clearly understand the exact steps which should be taken to secure immediate success in this work, and it is from this class of manufacturers that Mr. Porter is now receiving his largest patronage. There are very few men in this country who have had actual, personal, practical and successful experience along these lines, so that the work of Mr. Porter in this field is especially appreciated by, and valuable to, those employers who desire to be up to date in this branch. In addition to this work, Mr. Porter has an extended practice as consulting engineer in various lines of organization, for which, as this brief sketch has shown, his career thus far has splendidly equipped him.

He is a member of the American Society of Mechanical Engineers, the Iron and Steel Institute, the American Institute of Social Service, the Institute of Political and Social Science, the Franklin Institute of Philadelphia, and of the Engineers' Club, of New York City.

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STEAM • ELECTRICITY • POWER

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A RECENT PORTRAIT OF THE LATE JOHN CHRISTIAN KAFER

REPRODUCED BY PERMISSION FROM A PAINTING BY ORLANDO ROWLAND, OWNED BY THE ENGINEERS' CLUB, NEW YORK

SEE PAGE 190

CASSIER'S MAGAZINE

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EXTENDING THE USES OF ELECTRICITY

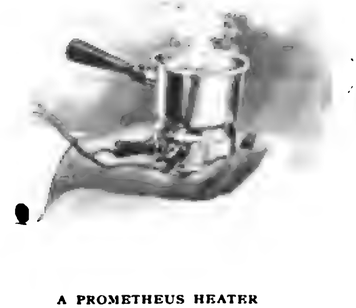
ITS APPLICATIONS TO DOMESTIC SERVICE

By H. S. Knowlton

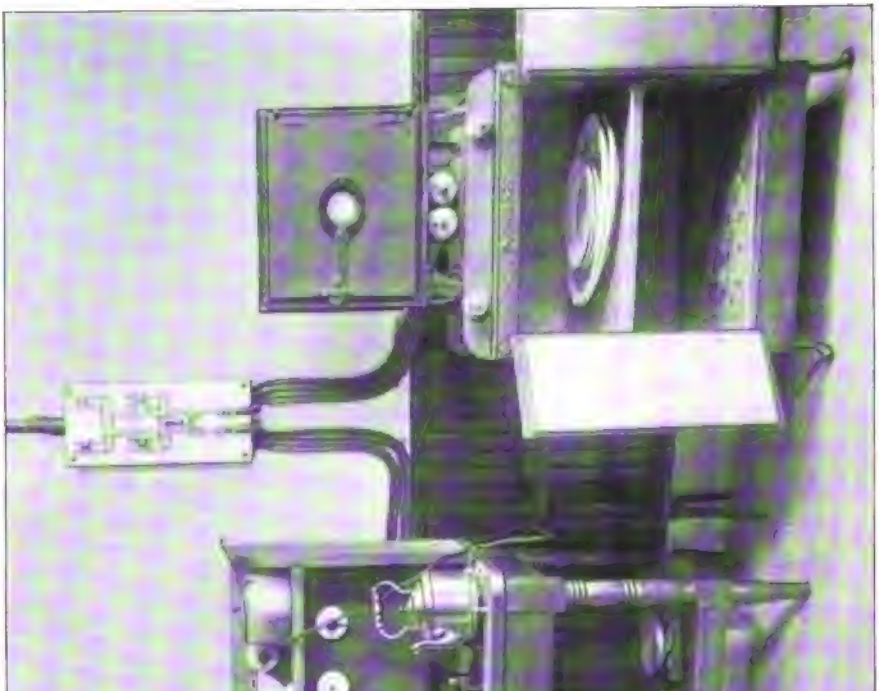
AN ELECTRICALLY HEATED LAUNDRY IRON

VIGOROUS efforts are now being made by progressive electric central station managers everywhere to extend the uses of electricity in dwellings, the fact being duly recognized that the opportunities in this field are far from being fully utilized. The experience of the telephone companies in the matter of residential service well illustrates the growth of business which the adoption of favourable rates tends to produce, and it is undoubtedly true that some such course in the central station field would bear good fruit. The rate problem, it is true, is a dangerous thing to tinker with, but the fact remains that in many places the residential business of local central stations is only a small fraction of what it might be.

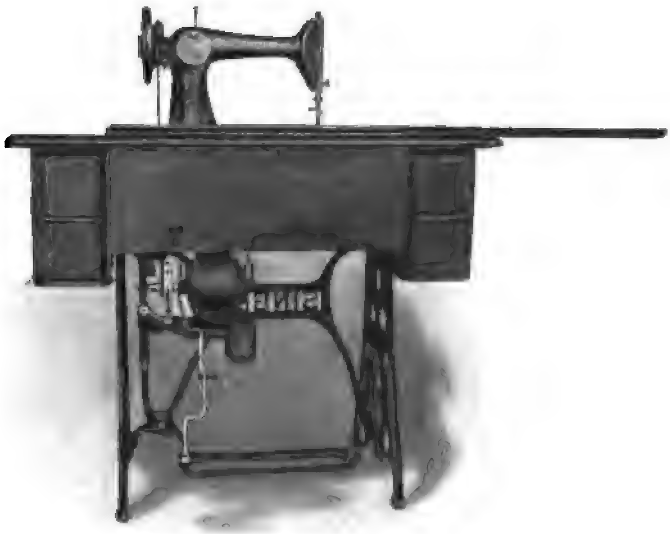
From the standpoint of the general public, almost any rate is likely to be assailed as too high, so that the clamour for reductions which is perpetually put forth by unthinking consumers should carry relatively little weight. With the present activity in the gas field, however, it behooves the central station manager to examine his residential rates carefully before deciding that nothing can be done to make them more attractive to



A PROMETHEUS HEATER



AN ELECTRIC KITCHEN OUTFIT INSTALLED BY THE SIMPLEX ELECTRIC HEATING CO., CAMBRIDGE, MASS.



A SEWING MACHINE DRIVEN BY AN ELECTRIC MOTOR MADE BY THE DIEHL MANUFACTURING COMPANY, ELIZABETHPORT, N. J.

the small consumer. On account of successive reductions in telephone rates in New England, the average revenue per telephone in exchange service has decreased in the last ten years from $83 to $37, but the resulting increase of business has been enormous, and 6 per cent. dividends have been declared with gratifying regularity. This is a heavy reduction—over 55 per cent. in fact—and while two public service industries as different as telephony and central station practice cannot be directly compared in financial policy, it is significant that prosperity has followed the reduction in telephone rates, even though the cost of service increases

A MODERN ELECTRIC BROILER MADE BY THE AMERICAN ELECTRICAL HEATER COMPANY, DETROIT, MICH. A MEDIUM-SIZED STEAK CAN BE COOKED WITH THIS DEVICE AT A COST OF TWO CENTS

FOR LIGHTING CIGARS ELECTRICALLY

AN ELECTRIC RADIATOR MADE BY THE PROMETHEUS ELECTRIC COMPANY, NEW YORK

with every new subscriber added to the system.

In the more progressive sections residences are now very generally equipped with electric lighting circuits, and the conduct, frequently found, of both the gas and electric light business by the same company has not always resulted in the neglect of the possibilities of the latter illuminant which is so common in some communities. It is a curious fact that even the heads of electric central station companies do not always enjoy electric light service in their own residences. Certainly any company which is actively pushing new business propositions should see to it that its responsible officers are consumers of its product, even if the service be supplied free of charge.

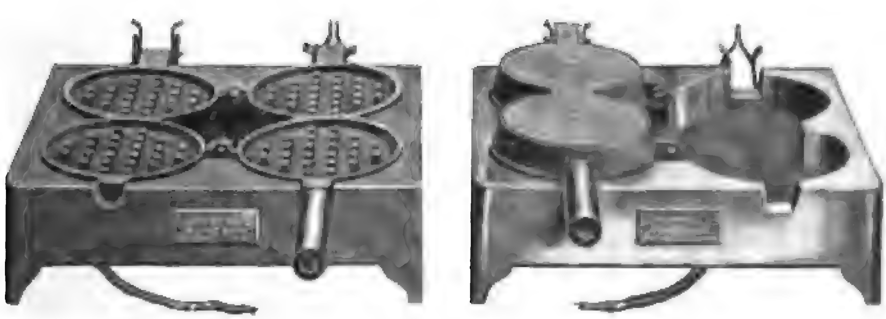
In a good many places electricity is regarded as a luxury, very desirable to have in one's residence, it is true, but expensive in comparison with gas. There is no use shutting one's eyes to the fact that this is the state of mind of many a gas consumer of moderate means, who would be only too glad to use electricity if

its cost were lower. Among the fairly well to do, it is not very difficult to convince the prospective consumer that with reasonable rates, even if these are somewhat greater than the corresponding gas tariff, the superior cleanliness, flexibility, convenience, and safety of electricity considerably outweigh the advantages of the older illuminant. But when we come to the man of small means, and the great majority of urban dwellers fall within this category, the only effective argument is an actual rate which compares favourably with the bill which he is accustomed to pay to the gas company. Very few town houses are now to be found which are not piped for gas, but far too many are not wired for electricity. It is a good plan for the central station to have on file the condition as regards gas or electric wiring of every house in its territory, preferably in card index form. It costs time and money to obtain such information, but it is worth all it costs, if the task is performed systematically.

The uses of electricity in domestic service are constantly increasing, and as the customer's means permit, so can he avail himself of them. Scarcely a week passes in any large city when the daily press does not record one or more fatal cases of gas poisoning, but it is a rare occurrence indeed when the electric wiring of a residence causes death through a transformer breakdown. The quality and hygiene of the incandescent lamp ought to finally place it in all but the poorest dwellings, but the work cannot be done unless the cost to the consumer is within his means.

CARPET SWEEPERS, TOO, ARE NOW ELECTRICALLY DRIVEN.—THE HUTCHISON ELECTRIC CARPET SWEEPER CO., PITTSBURG

The sewing machine motor has worked the physical salvation of many a housewife, but until the cost of its operation fits the average purse



ELECTRICALLY HEATED WAFFLE IRONS

A FLOOR POLISHING MACHINE WITH CROCKER-WHEELER ELECTRIC MOTOR DRIVE

its benefits must remain unknown by those who need it most of all. The polishing of tableware, grinding of coffee, chopping of meat, washing of dishes, cleaning and sweeping by motor-driven pneumatic exhausters, operation of cutlery grinders, ventilation of chambers and living rooms, sterilization of drinking water, and the operation of chafing dishes, curling irons and other heaters, are only a few of the things which the presence of electricity in a residence allows. Of course, many of these uses could not at once be enjoyed by the average family, and yet the simple introduction of a lighting circuit is the entering wedge of many good things to come.

The crux of the whole matter is simply this,—the central station man's motto must be, "Electricity in every home," to paraphrase the familiar slogan of the telephone companies. Possibly in some cases it will be found impossible to reduce the rates

for residential lighting much below the present charges, even figuring a liberal percentage of increased business as the result. The introduction of high-efficiency lamps will help considerably. Vigorous advertising will

AN ELECTRIC IMMERSION HEATER MADE BY THE AMERICAN ELECTRICAL HEATER COMPANY, DETROIT, MICH.—COILS OF THIS KIND ARE SPECIALLY ADAPTED FOR HEATING WATER OR OTHER LIQUIDS IN TANKS OR VESSELS, AND FOR THIS PURPOSE ARE TO BE PREFERRED TO DISC HEATERS OR HOT PLATES, BECAUSE THEY ARE NOT ONLY MUCH QUICKER IN ACTION, BUT ARE ALSO MORE ECONOMICAL AND DESIRABLE IN OTHER RESPECTS

AN ELECTRIC WARMING PAD MADE BY THE SIMPLEX ELECTRIC HEATING COMPANY, CAMBRIDGE, MASS. THE ELECTRIC WARMING PAD IS DESIGNED TO TAKE THE PLACE OF THE ORDINARY CUMBERSOME HOT-WATER BOTTLE. IT CONSISTS OF AN ELECTRIC HEATING ELEMENT, WITH AN OUTER CASING OF EIDERDOWN OR RUBBER CLOTH. THE OUTER CASING BEING REMOVABLE AND WASHABLE, SO THAT THE PAD MAY ALWAYS BE KEPT IN A SANITARY CONDITION

be useful, if it is brought home to the average citizen. Multiplied small profits are as good as a few large surpluses. In any case, it will pay to examine the residential rates carefully, and to definitely determine whether or not they can be made sufficiently attractive to the small consumer to make the gas-lighted home an exception, instead of the rule.

EXPLOITING AN INVENTION

By George Wetmore Colles

Concluded from the May Number

THE CONTRACT

IN the case of a few inventions, the investment necessary to exploit the patent may be trifling, while in some cases the inventor may have sufficient capital of his own to dispense with assistance from others. To such my remarks under this head will not apply. In the vast majority of cases, however, the proper financing of the invention requires the interesting of other investors. The question is how this may best be done.

The rules of law governing contracts are of great importance to the inventor, just as they are to every business man. In fact, in my belief there is not a single way in which the average college-trained engineer could so well employ his time after graduation as by getting a popular work on business law and making himself master of it. This would require, perhaps, as many as two hours a day for two or three months. But to the inventor it is especially important to know the various different ways of interesting capital, and their several advantages and objections, because it is just here that a vast number of inventors make a fatal slip.

The way that naturally occurs to almost every inventor is to sell an interest in his patent, meaning an undivided interest, as, for example, a half, quarter or eighth interest. He makes an assignment of such interest to the person interesting himself, in consideration of so much cash. This is about the worst form of agreement he could make. It is disadvantageous both to the inventor and his partner, or partners. It makes, in fact, an undivided and indivisible partnership, or joint tenancy, in the invention, which leaves either party to deal with the invention as he pleases without accounting to the other.

The assignment of an individual interest (which means any interest which is not limited as to territory, or as to use, or as to time, sales, or licenses, or in other like manner) places the inventor in the relation of a Siamese twin to his partner, with all the mutual disadvantages which that implies. It matters not whether one interest be one-tenth as big or ten times as big as the other, the disadvantage is still there; and whatever the proportion of interest, each has, in effect, the free and unrestrained use of the invention, and neither has the exclusive use.

In this condition it is practically impossible to negotiate the rights of either separately and the whole cannot be sold without the consent of both or all those having an interest. At the same time, either party could grant a license, territorial rights, etc., to the invention without the consent of the other, or without accounting to him for profits, for in so doing he sells only of his own. Thus the invention, instead of being a monopoly, may degenerate into a competition in which the interests of both are wrecked; or it may be equally wrecked from their failure to agree as to the manner of procedure. Of course, in many cases where both parties are reasonable and co-operate fairly with each other, no disadvantage results; but it is apt to re-

sult, and should be avoided both by inventor and capitalist.

This mode of contracting for capital is principally confined to those cases where the inventor lacks capital even to perfect or patent his invention, and consequently where a large interest is often given for a very small sum of money. It would be preferable, where possible, for the parties to form (with the assistance of a dummy where necessary) a corporation on the lines laid down in the next section, or, if the amount involved does not warrant the expense due to this course, to enter into a definite assignment contract, fixing not only the interests involved, but also certain exact relations and regulations as to the mutual conduct of the parties; as, for example, that such an amount shall be invested, that neither should sell his interest save with the other's consent, and that the invention should be salable, and that either would agree to sell his interest, to a third party, at a price fixed in advance; and so on, the various contingencies being carefully provided for.

After the undivided interest plan, the most natural method occurring is to interest some manufacturer in similar lines in the device, and to sell it to him outright for so much cash. But this plan is, in most cases, difficult to carry out, though where the invention is on its face a good one, there should be no difficulty in doing so. However, on this plan the inventor cannot hope to realize as much as he could by remaining interested in the invention and making a part of his compensation contingent on success, because the large risk taken by the manufacturer necessarily requires a large return if successful. The same article which the manufacturer buys for a thousand dollars might be sold by him the next year to another manufacturer for ten thousand dollars, and by the latter in the following year to a third manufacturer for a hundred thousand dollars, showing the great and rapid increment of value attained by patents as the sales under them increase.

The next and probably the most popular plan of interesting manufacturers is on the royalty basis; that is to say, the inventor makes an assignment of the patent to the manufacturer, in consideration of a royalty or percentage upon the sales of the patented articles, accompanied also not infrequently by the payment of a cash sum in addition. The royalty may be reckoned in various ways. It may be a flat sum per article,—so much per piece or per gross or per thousand; or it may be a percentage of the regular selling price of the articles; or again, a percentage of the net profits on them, that is, of the difference between the selling price and the cost of manufacture. It may, whether percentage or flat rate, be made to vary upwards or downwards as manufacturing increases, or from year to year, and in a simple or complex ratio. Again, it may be reckoned on the articles manufactured during each royalty period, or on those sold, or on those not merely sold, but actually delivered and paid for.

The difference in statement of the different conditions may seem inconsequential to an inexperienced person, and he will be apt to ignore it entirely if his attention is not called to it,—a fact which makes it possible for a shrewd party to get unreasonable advantage over the inventor; and it may be added that attorneys who are not experienced in this line of work are quite as apt to miss the point as the inventor is. In fact, even the experienced attorney finds it difficult to anticipate every possible contingency, however vigilant he may be. A contract of this sort, or of any sort which does not involve immediate execution in full by both parties, but is expected to be in force over a period of years, must, of necessity, be a long one to secure what it ought to secure to the benefit of the patentee by pro-

viding against these unforeseen contingencies.

Every royalty contract that does not provide for a considerable amount of cash down should provide for a minimum annual payment, for example, $500 on account of royalty, which not only serves to secure a certain minimum income to the inventor, but is also a pledge of good faith on the part of the manufacturer.

A still more advantageous agreement than any of the above is believed to be what I shall call the exclusive license plan. This provides that while the title to the patent remains with the inventor, the use of it, or such use as the parties may agree upon, shall vest in the manufacturer. Such a contract, of which the writer has drawn a number, generally provides that the penalty for failure to carry out any of the terms agreed upon shall be the lapse of the contract.

The great advantage of such a contract is that the inventor does not sign away his rights irrevocably, but that, on the contrary, they automatically revert to him by default, and he is not obliged to maintain a costly action at law to recover them or to recover damages. Such action might be far beyond the inventor's means, might be prolonged over years of time by appeals and the like, and might finally be defeated by legal technicalities; and, on the other hand, final recovery does not depend in any way upon the solvency of either party. The really serious and able manufacturer has no hesitation in entering into such a contract, as it involves no disadvantages to him so long as he fulfills his engagement, and, on the other hand, should the invention prove unsuccessful, he has the right to allow the contract to lapse and thus not stand responsible for further royalties.

How great the disadvantage is in assigning a patent or an interest therein on a contract for future payment, is probably fully realized only by those who have seen the consequences of doing so. It is not unlike the sale of a house for unsecured notes taken in payment, with this difference, however, that while the house can be taken on execution in payment for debt, the patent cannot. The title to a patent is an intangible property, which, in most cases, is practically out of reach of creditors. True, a mortgage can be taken upon it, and this is highly advisable wherever practicable in such a case. But this is often not practicable, and is not a frequent practice.

Next to the sale or exclusive lease of the patent as a whole comes the consideration of territorial grants. These again may take the form of outright assignment or of exclusive license over the territory in question. A country may be divided up into a number of sections and the rights for each section sold or leased to a different firm. This mode of handling an invention applies mostly to cases where there are many factories and where the trade of each is comparatively circumscribed; but the advantages of so dealing are very great, as one may often obtain from the sale of a single section as much as he could for the whole country, and still have a balance left. Moreover, if the device is made a success in one section, it is much easier to sell rights for the remaining sections at enhanced prices.

In connection with this matter I may call attention to one point in the assignment of rights under an invention. It ought always to be considered and stated precisely in the written paper whether the grant relates to all patent rights for the invention (i. e., in all countries of the world) or only for those in the home country, as well as whether the rights pertain to all patents for it, or merely to the particular patent referred to; and yet again whether or not the assignment covers improvements on the invention, and how far those improvements are to be included.

For example, in an assignment relative to a certain paper-box making machine, it should be clearly understood and stated whether the assignment covers merely the patent for the machine then pending or for other substitute and divisional patents as well; and if it covers "improvements," whether by this term is meant merely improvements coming under and dominated by the claims of the patent; or all improvements in that type of paper-box machine only; or improvements in any type of paper-box machine; or improvements in all box-machines, whether for paper or metal boxes.

The failure to state these points clearly is liable to lead to quarrelling and litigation. The assignment should also, for the protection of the assignee, obligate the assignor to execute any new patent application or other like papers which may be necessary to fully protect him under the terms of the assignment.

Next to territorial grants come local licenses or shop rights which are not exclusive. Not much can usually be realized from these individually; yet a great many may be sold by proper active work, either by the inventor personally or through agents. When once an invention is dealt with in this way it becomes unsalable as a whole, because there exists no monopoly in it. It is, however, the only way in which some inventions can be handled, more particularly widely used shop processes or methods; for example, a new cyaniding process for gold extraction, which could not be monopolized advantageously by any one firm.

There are also other ways of dealing with an invention which are advantageous in many cases. Where an invention is adapted to several different uses, or to use in several different lines of manufacture, it is invariably wisest to deal with each separately, as by so doing the inventor can, as it were, kill two birds with one stone,—in other words, sell two complete patent rights while owning really but one patent.

The manufacturer of flour, for example, is not interested in the manufacture of cement; so if a new process of grinding, equally applicable to both, be patented, the rights might be sold separately for the grinding of cereals and of clinker. The rights under a new line-reel were sold separately for use as a clothes-line holder and for a surveyor's tape, while the inventor still retained rights for other purposes, as for fishing tackle. Neither party who bought such rights was interested in the rights of the other, or would have paid any more for the whole than he did for the part. Such possibilities should always be carefully considered by the inventor before he disposes of any part of his invention.

The separate or divided assignment of parts or features of the patent, or of different claims thereof, is not admissible; for where such are divisible, one from the other, there should be two patents, and the courts have very properly held that the inclusion of both within one patent indicates that they belong to a single invention, one and indivisible.

THE PARTIES

It might be, and generally is, supposed by inventors that the party with whom they deal is a matter of comparative unimportance, the main point being to get the money. While, of course, this is the sine qua non, I wish to make it clear that the other is of great importance to ultimate success.

The advice, never to couple up with one given to dealings of which you cannot approve, whether as a matter of business honesty or business prudence, however great may be the seeming advantage of doing so, is as sound in this case as in every other. If you do, you are sure to regret it. One's business associates should be of the same general disposition as himself, although at the same time they should be endowed with those qualities,

e. g., foresight and executive ability, in which the inventor himself may be deficient. It is true that one cannot always select one's partner entirely as one would wish, but the alternative in many cases offering itself means the miscarriage of the entire venture.

Another important consideration is the amount of money obtainable. It frequently happens that one will part with an undivided interest in his invention to some person of small means for the mere cost of obtaining the patent, without leaving anything for other expenses. While this may do as a last resort in case the invention is not considered of any great value, it would, in most cases, be much better for the inventor to spend his money in promoting the invention and risk losing his patent through premature publication than to give away an interest for the mere cost of the patent.

Before entering into any arrangement of this sort, the inventor should assure himself of a definite amount of capital, reasonably sufficient not only to take out the patent, but to build models, make experiments, and do any necessary advertising or promoting to actually test the invention on a commercial scale. This fund will, of course, vary widely with different inventions, but it is well to figure on at least $250 to $500 in the majority of cases.

If such a fund be not provided at the start, then when the patent has been applied for and obtained, the inventor may be likely to find himself worse off than he was at the beginning, because he will have parted with a large fraction of his rights to another without having put the invention on a going basis. Then it may be necessary for the inventor to part with another large fraction of his interest to secure additional capital, so that he is left ultimately with a comparatively small amount.

It is, of course, necessary not merely to ascertain carefully the character of one's associates and to obtain a promise of a definite amount of money from them, but to ascertain that they are solvent and capable of fulfilling their engagements, and likely to do so. It is far better to have the amount proposed actually paid in and held on deposit, to be drawn on when needed; then, when need of it arises, there is no occasion for a controversy as to the amount of the assessment.

The question as to whether the invention shall be exploited by an established manufacturer or by a new concern is generally to be solved in favour of the latter. Experience shows that much more advantageous terms can usually be obtained by organizing a new corporation especially for the exploitation of the invention, than from a manufacturing firm with which this would be only one of many interests, and is apt to be neglected, or if not so, is in danger of passing out of the inventor's control.

In organizing a corporation, it is just as necessary to choose one's associates as it is in selling an undivided interest, supposing, of course, the inventor retains an interest (as he invariably must to inspire confidence in the others) either in the shape of royalties, shares, or contingent payments. The organizers and controllers of the company do not need to be mechanicians or persons of business prominence, but they should be men of affairs and able at least to know a good man when they see him, and to select such a one as the executive head, and follow his judgment.

If this is not the case, if the stockholders are persons ignorant of business affairs, incompetent either to manage a business concern themselves, or to perceive their shortcomings in this respect, the concern will, in nine cases out of ten, go to the wall before it has been long in existence, thus leaving the inventor worse off than if he had never attempted to exploit his invention.

The writer knows of cases where

a concern, organized from poor material at the start, failed, through poor business judgment, to realize its expectations, and, seeking to retrieve itself, brought in new capital under disadvantageous conditions, but failed to bring in good judgment with their additional capital, and thus went from bad to worse until it was hopelessly in the mire, and the question became not how to realize a profit, but how to disband without a loss. Such happenings reflect most injuriously upon the particular invention on which the company was founded, and yet the same device, handled in a proper manner, might have proved a great success.

It is unfortunately true that the number of those who unite inventive genius with executive ability and business sagacity is comparatively small, and inventors, as a class, are notoriously lacking in the respects mentioned. However, any man can distinguish between a business success and a business failure, between an experienced and an inexperienced person, between a practical man and a doctrinaire, and he should in every case see that the former and not the latter secures a controlling interest in the management of the corporation.

The question as to what interest the inventor himself should have in a corporation will be decided differently in different cases. Generally speaking, he should retain at least a minority interest, even if he has royalties in addition, not for the sake of getting additional returns, but in order to have some voice in the management. But if he retains royalties or other income apart from the dividends of the corporation, there are some reasons which make it unwise for him to assume any managing office in the corporation, especially one which would put him in a position to decide some question arising from his position as creditor. In default of owning any stock in the corporation, his contract should make proper provision for securing such influence for him as to enable him properly to protect his interest; for example, his consent to certain actions of the corporation and his right to inspect the books.

MARKETING THE INVENTION

The question of market is really the all-important question which comes before the inventor, and unfortunately one which is too often slighted. Hundreds of inventions are annually patented on which the inventor cannot realize for want of a market. Many inventions which are patented are undoubtedly useful in themselves, and applicable in a limited sphere; but either from the fact that they do not sell at a remunerative price, or that they are too easily home-made, or that the customers are few or difficult to get at, they fail in securing a market.

Some most excellent and ingenious inventions are constantly being made which would not be worth patenting because of their extremely limited use. Astronomical inventions, for example, often fall into this class. So do engineering improvements which are applicable only in rare and special cases, such as might be, for instance, a means of erecting a bridge-truss.

One good example in the writer's experience of an excellent machine that formed a long step in advance in its special art, but which would not pay to patent, was a machine for rolling leather cords for fly-nets. The machine itself accomplished with one operative what had theretofore required a much more expensive machine with six or eight operatives, and accomplished it much better; notwithstanding this, however, it would not have paid to patent it, because there were only a few competing firms, and because of the comparatively small annual output of fly-nets.

Another instance of a somewhat different character is an improvement in some article controlled by a trust. The improvement itself may be a valuable addition to the art, and in

an open market would find ready adoption, but the trust managers may not care to adopt it, because it would mean to them additional expense without any additional profit, and there is no other buyer. In short, the general principle may be laid down that once assured of a market, the success of the invention, with proper management, is certain.

The process of putting an invention on the market is not so simple as an inexperienced person is apt to suppose. It is usually necessary to create a public demand before the invention can be sold on any considerable scale, and it is necessary to follow up this demand by supplying the articles, otherwise the fruit of the labour in creating it will be lost. Of course, the manner of procedure will depend largely on the nature of the invention, but I here speak of articles of public consumption, which have a more or less general and distributed sale, and which are dealt with by the manufacturer in wholesale lots.

After figuring out carefully the net cost of manufacture, and fixing a reasonable wholesale price which leaves a margin of profit, the manufacturer next secures trial orders from various concerns. If the article is to be sold to manufacturing firms, it will be found that, however good the device may be, the firms will not take it up unless they can be assured of a reasonable certainty in the supply, for to do so would not only occasion expense in changing over their former system of manufacture, but would also subject them to disastrous losses in case they create a new demand with their customers which they subsequently find it impossible to fill.

The manufacturer, therefore, of the patented article must, if he wishes to make it a success, not seek for more orders than he can fill for the time being, and he must seek to obtain a steady continuance and enlarging of those orders. This is done sometimes by sending out solicitors on the road, sometimes by advertising in trade papers; in either case, it requires time and a considerable outlay before there is any certainty of returns. It is not a matter of a day or a month, or sometimes even of a year, for an invention such as a typewriter or an automobile usually requires many years and the expenditure of large sums of money before it can be considered as a staple article on the market.

Even the simpler devices are seldom, if ever, put out at first in the form which they finally assume, for they rarely fail to develop objections from customers which must be remedied,—either in the matter of material, or workmanship, or failure to operate properly, or cost. To overcome these objections requires further experimenting and new trials. Money at this critical stage must be supplied plentifully or the whole structure may tumble disastrously and all the investment be lost, and if this happens, it is generally more difficult to secure new capital than it was at the beginning.

It will be readily gathered from the foregoing remarks that an invention does not always succeed in proportion to its merits. One of great merit may fail absolutely for want of proper management, while another of very little merit may bring its promoter a rich reward. In fact, the case often arises where an unpatented device, involving very little inventive novelty, has been pushed to such good advantage and given results so much in excess of the manufacturer's expectations that it becomes necessary to obtain some sort of patent covering it, even though that patent covers very little worth covering, and acts rather to frighten off imitators than to actually restrain them from entering the same field.

Even where a patent cannot be obtained, it can be applied for, and the words "patent applied for" have, as is well known, a restraining effect in practice, if not in law.

MODERN GRINDING

METHODS AND MACHINES

By Joseph Horner

FIG. 1.—SPINDLES FOR A LARGE TURRET LATHE FINISHED BY GRINDING, BY ALFRED HERBERT, LTD., COVENTRY, ENGLAND. THESE ARE MADE OF VERY HARD STEEL, AND HAVE A 5¾-INCH HOLE THROUGH THE CENTER

DURING the past few years great advances have been made in the work of precision grinding. Precision work has grown far more than mere rough grinding, though the latter has been also greatly developed. But much of the so-called rough work is becoming of a precision kind, many of the old types of common machines being fitted with attachments and aids for holding and controlling the pieces being ground; and, further, new machines are being constantly introduced with the object of extending the practice of grinding into classes of manufacture that have hitherto been done exclusively in

FIG. 2.—AN INTERNAL GRINDING MACHINE, BUILT BY THE LANDIS TOOL COMPANY, WAYNESBORO, PA., U. S. A.

lathe, boring machine, planer, shaper, etc. Thus grinding machines are becoming differentiated under two broad groups, one including fine instruments of precision, the other machines for roughing down rapidly.

What separates the grinder from other machine tools and in some respects limits its utilities is the fact that the grinding wheels wear rapidly. A cutting tool, whether single-edged or in the form of multiple-edged cutters, retains its points or edges for a long period comparatively,—hours, or in some cases for two or three days. But the grinding wheel is necessarily losing particles of its grit every instant, and exposing others for successive duty, so that in the course of a single long traverse on a shaft, the diameter of a wheel becomes sensibly reduced. The effect of this is neutralized by the selection of grades suitable for roughing and finishing, respectively, and by taking very fine finishing cuts, which do not appreciably wear the wheels. In both circular and face work very accurate results may be thus obtained, though the wheels are wearing away every moment.

But such wear cannot be neutral-

ized in that large class of work which involves profiled outlines, because a profiled wheel cannot traverse. Here the grinder is unable to compete with the lathe, the profiling tools, and the milling machine. The only profiled wheels that can be employed with advantage are those with plain convex edges, or wedge-shaped edges, used chiefly for saw grinding. A profiled wheel of elaborate section would lose its shape almost immediately; hence the only profiled precision forms which can be produced by grinding are simple curves. These, of which the slot link is typical, can be done readily because they permit of the reciprocation of the wheel in a curvilinear path, which must be done to prevent grooving both of it and of the surface ground, and which is practicable only when the grinding edge is straight.

With this exception we have the apparent paradox that a wheel which wears rapidly, and uses some of its particles with every revolution it makes, is yet capable of producing more accurate results than any cutting tool of hardened steel used in lathe, planer, or milling machine; and it is due to the precision obtained by grinding that the grinding machines themselves can be made so accurate as to be able to produce results measured in fractions of a thousandth of an inch, and also that instruments of measurement can be turned out both cheaply and accurately enough to test such dimensions. These results depend on the truth of circular and plane surfaces produced by the grinder, and left as they leave the grinder, without corrective scraping.

Further, the grinder will do what no other mechanical process is capable of effecting; it will true hardened and case-hardened work as readily as softened, or annealed, pieces. To this fact the increase in the employment of hardened spindles and bearings in numerous classes of work, as well as in machine tools, is wholly due.

At the present time grinding machines are so numerous that classification, except of the broadest, becomes difficult. Even if we omit the immense groups of non-precision machines, there yet remain a much

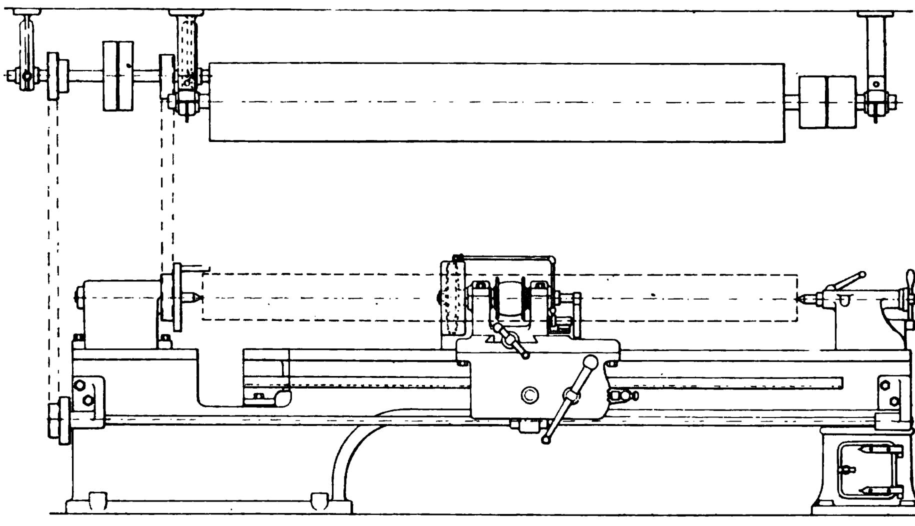


FIG. 3.—GRINDING MACHINE FOR SHAFTS UP TO 8 INCHES IN DIAMETER AND 8½ FEET LONG. MADE BY MESSRS. POLLOCK & MACNAB, LTD., MANCHESTER, ENGLAND

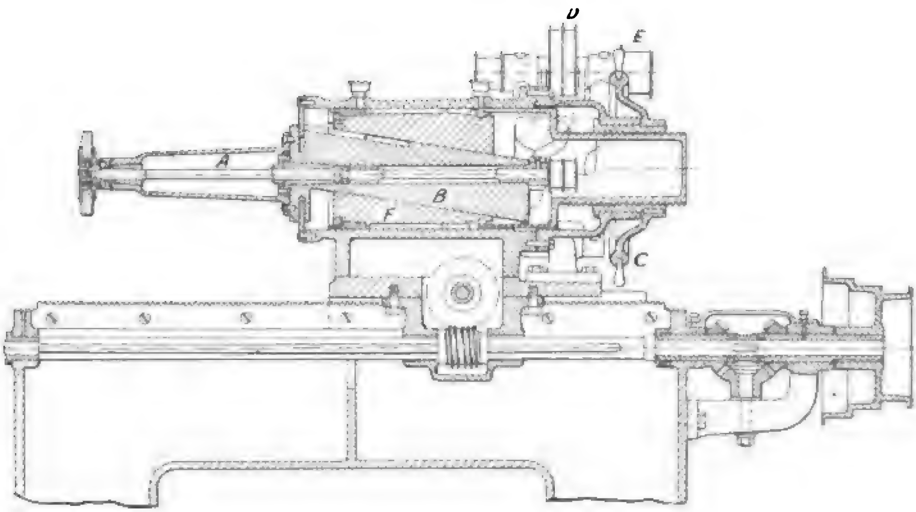


FIG. 4.—ECCENTRIC GRINDING SPINDLE FOR HOLES, MADE BY MESSRS. MAYER & SCHMIDT, OFFENBACH ON THE MAIN, GERMANY

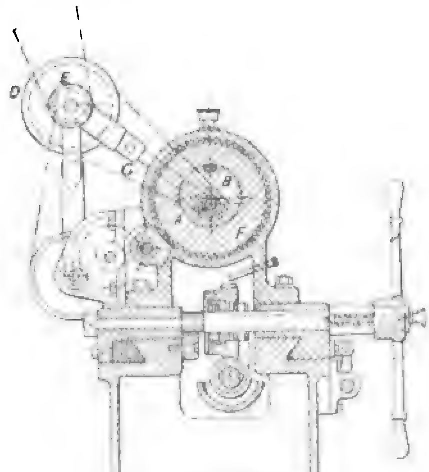


FIG. 5.—CROSS SECTION AND END VIEW OF FIG. 4

larger number of precision types. A comprehensive grouping would be plain surfacing, plain cylindrical, universal tool grinders, and special machines.

Plain surfacing machines include many which are built on the planer model, and others on the vertical boring mill model, besides the numerous disc grinders. Plain cylindrical machines are both of large and small dimensions for grinding long rolls, axles, shafts, and for small spindles. The universal machines are capable of doing all kinds of plain and cylindrical work, including the grinding of holes and faces. The tool grinders are divisible into three groups, the milling cutter grinders, the twist drill grinders, and the plain tool grinders. The special machines include numerous examples for slot links, for the bearings in coupling rods, for the bores of cylinders, and others. It is clearly impossible to give even a general account of all these within the compass of one article, but we may discuss their principal elements, leaving the illustrations to indicate much of their detail.

Plain surfacing machines are built after various models, from that of the simple disc or edge wheel to which the work is presented by hand on a table of some kind, to the planer model machine, in which the work is bolted to the table and the feeds are graduated to thickness by definite minute fractional parts.

Machines of the first kind are links between the non-precision grinders and the precision planer types. A horizontal work table over the wheel, hinged and adjustable with a screw and hand wheel to regulate the amount of projection of the

wheel through the table, is a frequent form. It is precise, though not in the highest sense of permitting of measurement by rule divisions. A similar remark applies to work laid on fixed or movable tables, or on angle brackets, or rests, and presented to the edges of wheels, or the faces of disc wheels, and traversed across those edges or faces. Accurate results are often obtainable, though not by measurement, and this limits the utilities of these machines. They are so valuable, however, in covering a large range of shop work which is not required "precise," but only finished, that large numbers of such designs are in existence. Many of these come from Germany.

The disc grinders, which have developed rapidly during the past half-dozen years, must be regarded as a much specialized group, in most of which the tables have provision for precision movements towards the discs, and precise angular settings by protractor for grinding edges. When the slots and clamps are included in the tables of these machines, they become, with the foregoing provisions, precision tools for plane surfaces.

The growth of the machines, broadly grouped as of the planer model, is remarkable even in the history of grinding machines. In this model, the open-side kind of machine occurs as well as the double housing type. With these must be included numerous sub-groups, built after the models of the common shaper, of the face lathe, the rotary planer, and also of the pillar-and-knee type of milling machine, and of the planer-miller, using both edge and face wheels; or, in other words, having horizontal and vertical spindles. Finally, there is the vertical boring mill type, using edge wheels over a revolving table which carries the work.

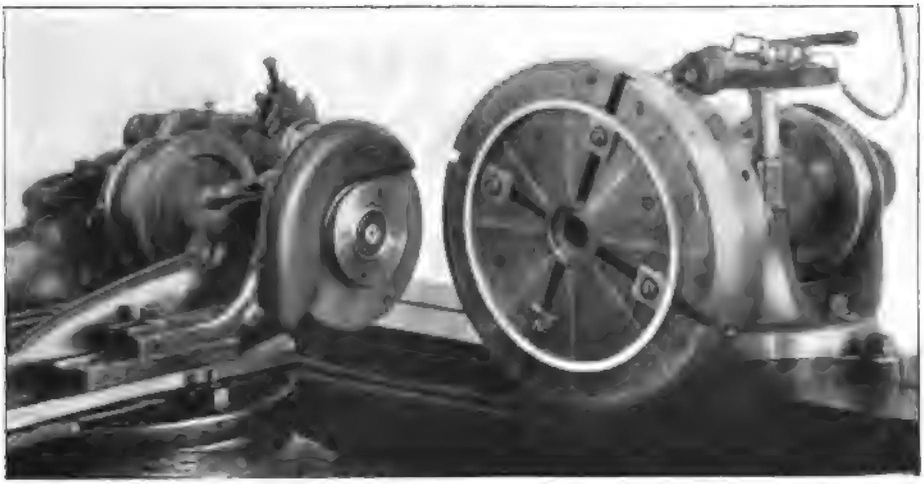


FIG. 6.—HOLDING A FLIMSY RING WITH A MAGNETIC CHUCK WHILE GRINDING THE FACE. THESE CHUCKS ARE MADE BY MESSRS. O. S. WALKER & CO., WORCESTER, MASS., U. S. A.

Each of these occurs in several modified designs. The builders of grinding machines of these classes have, therefore, followed in the main pre-existing machine models, not only in regard to their general features, but into many of the details of the operating mechanisms.

The broad distinction, however, between these groups of machines and those on the models of which they are built lies in the necessity for producing a traversing movement between the wheel and the sur-

face of the work being ground. In some way or another this must be done in all machines, and whether it is imparted to the wheel or the work is only a question of convenience. Sometimes the wheel is traversed, sometimes the table,—the movement in either case being a reciprocating one. In the highest classes of machines the reciprocations are made automatic by stops, levers, and springs mostly, similar to those employed on the common machines using cutting tools. The feeds for thicknesses are also capable of adjustment as well as being made automatic.

Cylindrical grinders are of two main classes,—those used for external surfaces and those for internal. Another group, having much in common, combines both functions with that of cutter-grinding of all kinds; hence the term universal, applied to these.

The circular plain grinder, pure and simple, is not used to the same extent as the universal type, being reserved chiefly for special work in specialized shops, as axle and shaft grinding. Its construction, however, is simple by comparison with the universals, though the tendency is always to add something to it to increase its utility, such as a taper grinding fitting or an internal grinding fixture. Fig. 3 shows a machine by Messrs. Pollock & Macnab, Ltd., representing the general design of a plain shaft grinder. The wheel is traversed by the carriage, of front apron type, reversed and stopped by the lever seen in front. The grinding wheel is enclosed by a hood, with a shoot for conveying liquid into a trough down the centre of the bed. A pump is fixed on the grinding rest at the opposite end to the wheel, thus travelling with it. One of the two countershafts drives the grinding spindle by fast and loose pulleys through the intermediary of the long drum; the other, with fast and loose pulleys at the left, rotates the headstock spindle and operates the longitudinal feed through two-stepped cones.

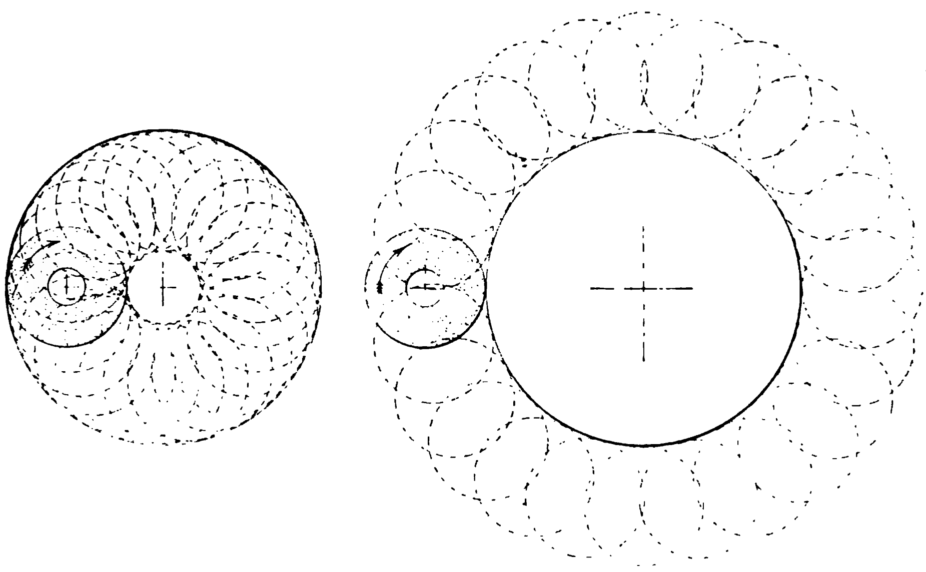


FIG. 7.—THE DIAGRAM AT THE LEFT SHOWS THE PATH OF A GRINDING WHEEL ON A PLANET SPINDLE, TRUING UP A HOLE. THE RIGHT-HAND DIAGRAM SHOWS THE PATH IN TRUING A PIN

The plain circular grinders do not

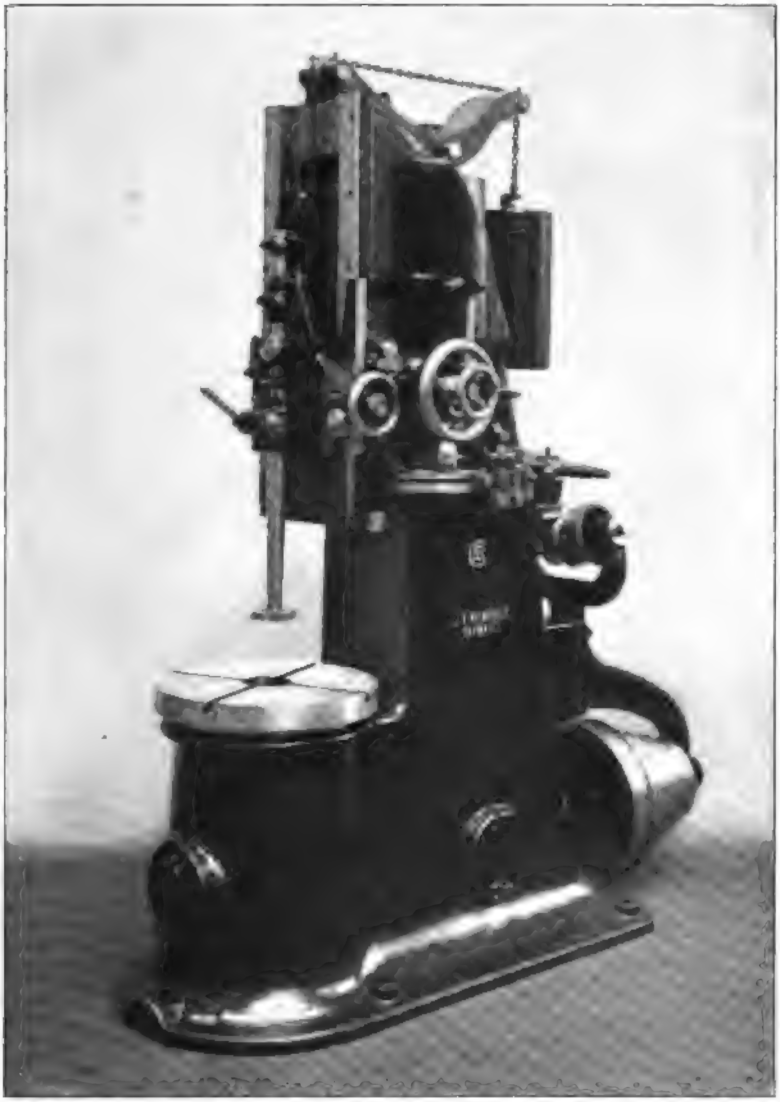


FIG. 8.—VERTICAL-SPINDLE MACHINE FOR GRINDING HOLES UP TO 14 INCHES IN DIAMETER. BUILT BY J. E. REINECKER, CHEMNITZ-GABLENZ, GERMANY

constitute so large a group as those which are designed for internal grinding wholly or primarily. Holes and bushes, hardened or unhardened, and slots and slot links form so large a section of the work of some shops that the machines in this group are very numerous, although of comparatively recent development.

We all remember the old practice of lapping holes in the lathe with lead laps cast on iron mandrels, and charged with emery. They were run between centres, and piles of them were stored on stands, and are still to be seen in many shops, not wholly displaced by the solid emery wheel. But it was bad for the slides of the lathes; and there was no precision in the results in the sense of work-

FIG. 9.—A DOUBLE SPINDLE HOLE GRINDER BUILT BY FRIEDRICH SCHMALTZ, OFFENBACH ON THE MAIN, GERMANY

ing to absolute dimensions, though for making mutual fits they were admirable.

The next advance was to fit up little bench-grinding machines to carry emery wheels of small diameters, and of lengths much greater than the diameter, similar to the proportions of laps. These are used extensively for hole and concave grinding, the pieces of work being held in and traversed by the hands. Here, too, precision is wanting. But within their sphere, which is large, these machines are very useful in most shops doing work for which otherwise rough smoothing with a file or rough boring would be "good enough." Attachments are also made to common lathes for doing internal grinding.

The movements required for in-

ternal grinding, when the control of the hands is not available, are less simple than those which answer for external work, whether plain or cylindrical. In the latter the wear of the wheel is readily compensated for by feeding it forwards after each traverse. If the work revolves, as in universal machines, the simple feeding is available, but that covers only a small amount of hole grinding,—little more, in fact, than that of bushes. It does not touch that great volume of work that must be fixed during the lapping-out of holes, and for doing which the emery wheel must not only rotate, but its axis must also describe a circular path.

The question of the choice of non-eccentric or eccentric grinding spindles is not difficult to settle. The first is suitable for small pieces that can be rotated. As the grinding wheel also rotates and traverses, the conditions of accurate work are present. Enlargement of diameter is secured by feeding the wheel radially to the work. This is how the hole-grinding is done in circular and universal machines. But take a coupling rod, or a large bearing bracket, or similar article, and the difficulty of swinging such articles around is practically insuperable. As they must, therefore, be fixed, it is clearly necessary to impart a circular motion to the grinding wheel, for a wheel on a rigid spindle, though it could be fed outwards, or perpendicularly to the surface, would not grind a fixed cylinder unless it could also be traversed around the bore. Then, its radial movement must also be capable of fine adjustment if precise dimensions are to be secured.

Several ingenious devices of the sun-and-planet drive, or of a more simple eccentric movement, are employed to effect these motions. In these the grinding spindle is enclosed in a main bearing within which it

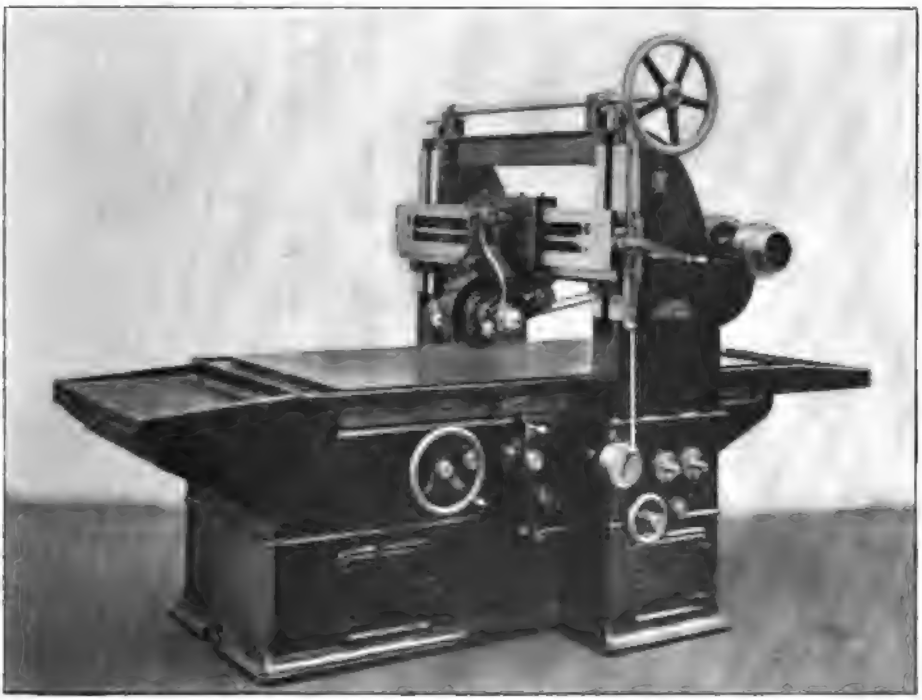


FIG. 10.—PLANER TYPE SURFACE GRINDING MACHINE BUILT BY J. E. REINECKER

FIG. II.—ANOTHER SURFACE GRINDER, BUILT BY J. E. REINECKER, CHEMNITZ-GABLENZ. GREATEST LENGTH GROUND, 23½ INCHES

possesses a graduated eccentric movement from maximum to nothing. At the latter, it can be used as a plain spindle. In one design a parallel fitting alone is employed; in another it is combined with diagonal bushing.

In a machine built by Friedrich Schmaltz, of Offenbach-on-the-Main, Germany, the spindle runs in a parallel sleeve. It is rotated at a high rate by a small belt pulley. The sleeve and spindle are revolved slowly by a belt pulley, or by worm gear encircling an outer casing, so carrying the spindle in its sleeve round in a circle. The adjustment for eccentricity is effected in various ways. In one the belt sleeve carries a fork-encircled bush, a set pin passing through, which enters the cam slot in the spindle sleeve. As the bush is moved up or down by a hand wheel and screw, the pin in the cam groove constrains the motion of the sleeve circularly, so altering its

degree of eccentricity by minute amounts, reckoned by the five-thousandth part of an inch. The design is varied in some machines, a gear wheel drive being sometimes substituted for the belt. Vertical and horizontal-spindle machines are also made with the same type of spindle.

In the design of Messrs. Mayer & Schmidt the grinding spindle *A*, Figs. 4 and 5, is carried in an eccentric sleeve *B* having its axis set at considerable angle. The amount of its eccentricity is regulated by longitudinal adjustments of the sleeve by means of a hand wheel *C*,—backwards or towards the hand wheel to diminish the eccentricity, forward to increase its amount. The rotational movements are interesting. Both that of the wheel spindle and of the sleeve are taken from the same shaft with pulleys *D E* nearly alike in diameter. But the spindle-drive takes place direct; the sleeve drive, indirectly through gears, so that while the spindle makes 7000 revolutions, the sleeve makes only 30. The latter is driven through a compound train of five gears, the last of which engages with teeth cut on the bush *F*, and is of sufficient length to keep in engagement at any position of longitudinal adjustment.

The tension of the spindle belt is maintained at any radial position of the spindle by a telescopic rod *G*, which can be clamped in its socket. The spindle sleeve is compelled to rotate in its bushing by a key and groove. Around these elements the designs of numerous hole-grinding machines are built with vertical and horizontal spindles, and, as we have already observed in the plane surface grinders, following the obvious designs of machine tools used for ordinary cutting processes. It is also clear that a wheel rotating in a circular path is able to grind the outsides of pieces as well as the insides of holes. Fig. 7 illustrates these operations.

The grinding wheels used in these designs are not thick, like those of the machines in which the work is traversed by hand, where the length of the wheel affords some valuable guidance. They are thin, just as on the circular grinders, and the necessary traverse is imparted to the spindle head. This is in harmony with the best practice in grinding, namely, to have thin wheels which permit the swarf to get away freely.

Spindles and their heads can be duplicated to grind holes set and adjusted at centres, as illustrated by the Schmaltz machine, in Fig. 9. The form principle, or the radius arm, is also often embodied, and curved edges are ground with accuracy. Both of these devices are most useful in locomotive shops, and around all these numerous machines are built. Whether machines shall be of the vertical or horizontal-spindle type is a question of convenience only, being one similar to that which so often recurs in connection with vertical and horizontal-spindle lathes.

Some of the vertical-spindle machines are built on the vertical drilling or milling machine model, with a single spindle, a knee bracket, and table capable of vertical adjustment. Others have two spindles with their saddles adjustable along a cross rail to grind two holes to exact centres, as in coupling rods, or holes in separate pieces of work.

The horizontal types range from simple to complex forms. In the simplest, a bracket, bolted to one end of a bed similar to that of a lathe, receives the work on its vertical face, slotted for bolts. The spindle, driven from two overhead drums, one for rotation, and one for movement in a circular path, is racked along by hand for traverse feed. In a better machine the fixed bracket carries a face-plate over a deep gap, with adjustments by hand wheel and screw for vertical movements of the work, and a rotary movement by worm and wheel. The spindle head has a self-acting feed, and reversal by means of a screw running along the bed, and clutched bevels, the

movement being derived from over head. The face-plate for the work is further varied in design to take long pieces, and with provision for transverse and angular adjustments. Some of these machines are without gaps. Other horizontal-spindle machines resemble the pillar-and-knee milling machine, including the telescopic shaft for the table feeds. The spindle has the sun-and-planet motion.

Allied to the foregoing are the slot link grinders, the same movements being utilized with the necessary additions of radial rods. In some cases these rods are arranged horizontally, in others vertically; and in the latter sometimes above the link, sometimes below. The mechanism of these can hardly be illustrated satisfactorily in an article dealing with grinding in general, besides which perhaps a dozen different designs of such machines are now made.

The concluding part of this article, in the July number, will deal with universal and special grinding machines

SOME MODERN BUSINESS AUTOMOBILES

AUTOMOBILE IMPROVEMENTS

SECURING GREATER RELIABILITY AND ENDURANCE

By George Ethelbert Walsh

IN spite of its remarkable growth, its great development as an efficient and helpful machine, its adaptation to many kinds of work, and its unexampled popularity as a vehicle for pleasure and ordinary traction purposes, the automobile is still in its swaddling clothes—a prodigy among infants, it may be—but nevertheless young in years and potential development.

As an industrial factor of portentious importance, the manufacture of automobiles has for a number of years confounded all statisticians and prophets, and this phase of its development has been amply dwelt upon. The number of concerns with

money invested in the manufacture of automobiles is almost legion, and new ones continue to spring into existence every year. Already this work has reached the stage where many factories are in operation which claim no distinction to originating new types of machines, or, for that matter, which hold any right to basic patents or new improvements. They are content to assemble the machines, buying the different parts from various concerns which control the patents, and thus place on the market automobiles at the lowest price consistent with good workmanship. This naturally has tended to specialize the work of manufacture. Large concerns have entered into the production of automobile wheels, axles, springs, mufflers, tonneaus, engines, storage batteries, igniters, and dozens of other specialties. This tendency to specialize the work is spreading more and more.

In a great many cases this results in general improvement of the average machine. One plant can design and produce a few specialties for stock trade better than another which tries to control under one establishment the manufacture of a large number of parts. The invention of costly machinery to produce individual parts at a lower ratio of cost has made itself felt in the trade. Even the large plants which control basic patents on their special types of machines, purchase many of their minor parts from manufacturers who have perfected them through the use and application of special machinery.

Speed, reliability, endurance, and cost are the chief factors that enter into the manufacture of the modern automobile. In the matter of speed, the automobile probably has reached its limit, except for distinct racing purposes. It has already demonstrated its superiority to almost any other form of vehicle in this respect, and unless automobile highways devoted exclusively to the use of the machine are built, the present speed is sufficient for all practical purposes. A projected automobile highway between London and Brighton, and the proposal of a similar four-track highway between Philadelphia and New York, may indicate the dawning of a new era when speed for ordinary purposes will enter more largely into the problem of manufacture. Such highways would have two tracks for speeding, and two for slower vehicles.

Reliability and endurance, however, are much more important factors in the present movement than speed. The cars of 1906 emphasize these points in many ways. The automobile must prove its reliability under most severe tests to make its value more universal than it is to-day. The endurance tests made by operators of different types of machines in the past year or two indicate the popular demand for machines that can be relied upon under the most unfavourable conditions. Reliability, however, is an inclusive word, and can be stretched to cover a multitude of things. It appeals to the manufacturer in a thousand different ways. It means perfect unit construction; it even goes back of any of these, and begins with the manufacture of the metals which compose the parts.

Automobile steel occupies a position unique in the history of steel making. Not even the builders of steam and electric locomotives and railway cars have demanded of the steel makers more superior grades of metal than some of the leading automobile companies.

Reliability of the motor, steering apparatus, and transmission gear comes next to the reliability of the steel. The motors of the 1906 cars are not, as a rule, more powerful than their predecessors, but they are safeguarded by more devices against breakdowns. Parts of them where the strain has been found to be the heaviest have been made of heavier metal. This is particularly true in the new heavy touring car, with its four cylinders, and 25 to 30 H. P., weighing in the aggregate some 2000

to 2400 pounds. These standard touring cars have approached the French make in many particulars. The engines, besides having their weak parts strengthened, are provided with superior oiling facilities. The danger of heating by friction is nearly entirely eliminated by a continuous circulation of oil throughout the bearings. In most of these cars the oil that is forced to all parts of the engine must first pass through a glass visible in front, so that the supply can always be watched. Nothing but foolish or criminal neglect is, therefore, likely to produce overheating from friction.

While a certain amount of human oversight and attention is demanded in the operation of an automobile, the tendency is to make every part automatic and mechanically perfect. This is imperative, because the average driver must be considered as being comparatively unfamiliar with machinery. Mechanical devices are therefore needed to counterbalance any neglect or ignorance on the part of inexperienced drivers. The safety of the owners must depend chiefly upon the automatic operation of the machines.

The question of safety is intimately connected with the relative reliability of an automobile, and many of the newer devices introduced in the manufacture of the up-to-date machine are intended as checks against accidents of a serious nature. The speed and steering control, and the manipulation of powerful brakes, are all primarily designed with this end in view. The brake control has reached a degree of perfection where it would seem as if mishaps in emergencies could not follow. But secondary brakes and automatic brakes acting in emergencies independent of the human brake control are safety guards which have found their way into a number of the new machines. Any derangement of the main brake would not interfere with the secondary automatic brake, which operates only under certain high speeds and when the brake lever is thrust far back.

Likewise, the question of secondary or independent steering control has been openly advocated and experimented with, but so far little has been done in this direction. However, it is apparent that there is a demand for it in high-speed cars. The danger in an accident to the steering apparatus is that a driver loses complete control of his machine. A more helpless condition can hardly be imagined, especially if the brake also should fail to operate. The reliance upon a secondary or independent control would immediately change this aspect of the question. Such extra control could be operated either automatically or by hand.

Considerations of comfort in the new cars have been amply provided for, and the latest automobile, whether of the two or four-cylinder type, is the easiest and most luxurious vehicle yet invented for fast road traveling. Numerous mechanical devices have helped to achieve this result. Shock-absorbers have been perfected so that the vibration to the car seat is scarcely noticeable. There are many designs of shock-absorbers and rebound-checking devices, and they perform their work with success. Ball bearings have been utilized in a greater measure than ever before, both for engine shafts and axles. This gives not only a much easier drive to the machine, but it adds to the comfort and smoothness of the running. Heavier wheels, ranging from 32 to 34 inches in diameter, are features of the newest cars, and also a tendency to increase the size of the pneumatic tires.

Air-cooled motors have made a distinct advance in the past year. A year ago they were considered failures by many, and their increasing popularity raises the question as to whether they may not become the standard type of the near future. They are placed on many of the most powerful cars. They vary somewhat in type. Most of them depend upon

a fan for cooling, but in a few cases the cylinders themselves revolve. So far these high-powered air-cooled motors have given satisfaction.

The tendency in the manufacture of electric automobiles is of more than general significance. The electrically propelled vehicle has its own distinct problems, but inventors are not discouraged in trying to overcome them. It would be strange indeed if electricity, succeeding in so many other fields, should fail in automobiling. The cost of operation, and the range of running without recharging, are the two vital points to be considered. So far as comfort is concerned, the electric automobile still holds supremacy. The absence of gasoline odour, heavy throbbing and noisy explosions, and the simplicity of equipment of the motors and transmission gear, all make the electric machine an unusually agreeable and desirable vehicle.

In one particular line the electric automobile has held the lead for several years, and improvements of the past year have tended to increase this lead. In nearly all phases of city life where short runs only are needed, the electric automobile truck, delivery wagon and coupé have displaced the gasoline car. The latter finds its higher speed and long-distance capacities of no great advantage in the city, and the electric vehicle answers all requirements without any of the nuisances so intimately connected with the use of gasoline for power purposes.

Tests and experiments continue to be made in the laboratories of those interested in the different types of batteries used for automobiles. Batteries of the Edison type, or the nickel-iron type, may be, bulk for bulk, lighter than those of the lead type, but the ideal battery should have a higher voltage, and consequently fewer cells. Nevertheless, the batteries and operating machinery of the electric automobile have been improved in the past year to such an extent that the cost of running them has been materially reduced. This is a gain of great value. The distance of the run also has been increased. A number of long-distance runs, averaging from 80 to 100 miles, have been made in America with electric vehicles over ordinary rough roads, and in France a run has been made from Paris to Trouville with one charge, extending the possible limit to 130 miles.

SOME HIGH-PRESSURE STEAM PIPE DETAILS

By James Acton Miller

IT has not been very many years that wrought pipe has been in use, although one would think, because of its common adaptation to-day that it has been in the same service for all time. Its use now is so universal that we wonder what was done before it was perfected.

The same is true as to the manner of its use, as fittings that are applied to various piping jobs have only recently been perfected, or, in fact, it might be said are not perfected yet. A few years back there were no fittings of any kind that could be utilized for any purpose for making deflections in a line of pipe, and comparatively young men can remember when everything of that kind was made on the spot. In fact, this was the case up to within a few years, and in some places to-day wrought bends have to be largely depended upon for elbows and other uses in piping.

It is also a well-known fact that there were no appliances in the earlier days for making pipe bends on the job; the piper had to depend wholly upon his own strength for getting the line of pipe into position, and this brings out the fact that a line that was larger than 2 inches was an exception. Up to even twenty-five years ago anything larger was rarely used; to-day 30-inch wrought iron pipe is common.

At those earlier times referred to, the necessity was ever present for making bends in the pipe to be used; in fact, nothing else could be done, whereas now, if even a half-inch elbow is lacking when the job comes to that point, the helper is sent to the shop to get it, often consuming hours of valuable time in doing this, when the old-time piper would simply have brought his knee into requisition, bent the pipe around that ever-present former, and placed it in position before the modern helper would have gone a square toward the shop for supplying the elbow now considered indispensable.

This was the case with all sizes of pipes used at that time. Bends were made preferably to using or trying to use anything else, and a virtue was thus made of necessity. It was a long while before fittings were generally adopted, even after they became a common article of manufacture. It was thought that work could be done better without them, as the pipe was then made so as to stand bending cold. But when the enormous demand for pipe sprang up and the use of butt weld and steel pipe crept in, it soon became next to impossible to bend pipe at all without the best of appliances, and doing much bending on the job was not to be thought of.

The necessity for the use of wrought bends has again come to the front within the last few years, especially in the larger sizes, but from an entirely different reason. Steam pressures for various uses have increased so rapidly to keep pace with high-pressure business methods generally, that pipe bends are looked upon as a positive necessity in a great many places.

In point of fact, however, properly made wrought bends can be used

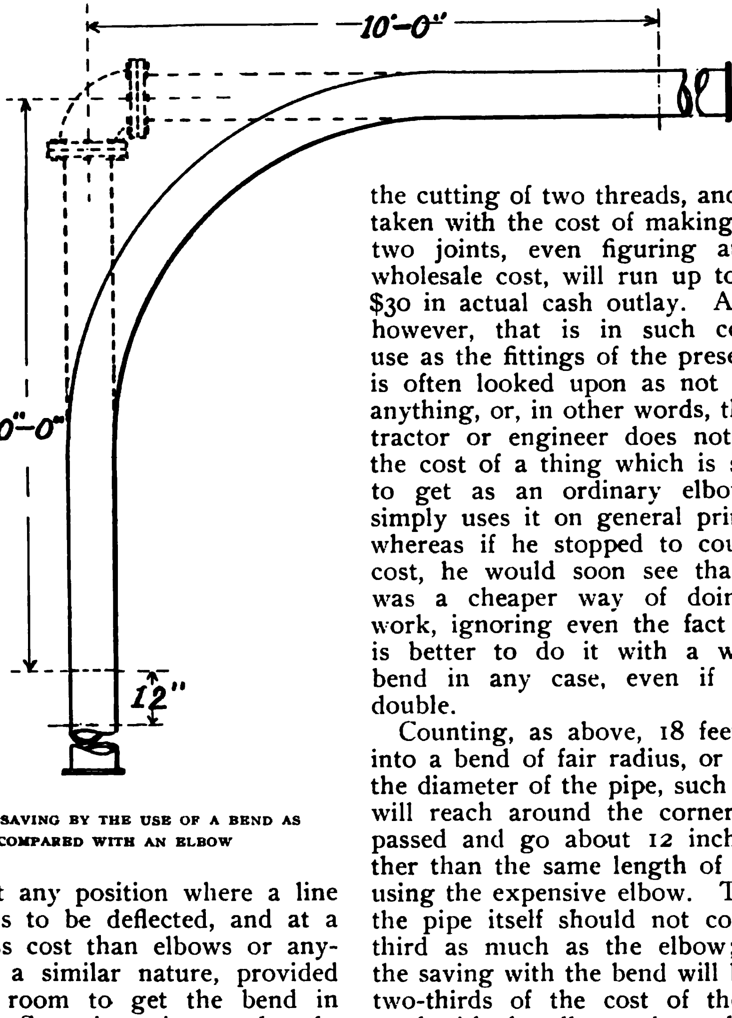


FIG. 1.—SAVING BY THE USE OF A BEND AS COMPARED WITH AN ELBOW

in almost any position where a line of pipe is to be deflected, and at a much less cost than elbows or anything of a similar nature, provided there is room to get the bend in position. Sometimes it may be absolutely necessary to use elbows to get in sharp corners or do close work getting around obstructions.

Fig. 1 illustrates the relative saving to be effected in passing around a corner with a line of piping, and makes the meaning of the above statement clearer than words can do it. It will be seen that to use an elbow in a run of piping, and measuring, say, 10 feet each way in the line, taking 10-inch pipe to illustrate the case, will require about 18 feet of pipe and a long-radius, extra-heavy cast iron elbow, two companion flanges, two gaskets, two sets of bolts, and the cutting of two threads, and these, taken with the cost of making up the two joints, even figuring at close wholesale cost, will run up to about $30 in actual cash outlay. A thing, however, that is in such common use as the fittings of the present day is often looked upon as not costing anything, or, in other words, the contractor or engineer does not figure the cost of a thing which is so easy to get as an ordinary elbow, but simply uses it on general principles, whereas if he stopped to count the cost, he would soon see that there was a cheaper way of doing this work, ignoring even the fact that it is better to do it with a wrought bend in any case, even if it cost double.

Counting, as above, 18 feet made into a bend of fair radius, or 8 times the diameter of the pipe, such a bend will reach around the corner to be passed and go about 12 inches farther than the same length of pipe in using the expensive elbow. To bend the pipe itself should not cost one-third as much as the elbow; hence the saving with the bend will be fully two-thirds of the cost of the parts used with the elbow; about the same length of pipe is necessary in both cases.

From this it would seem that there is no saving in using ordinary fittings as applied in this class of work, but at the same time, after the job is up, the difference in cost has only commenced, as the friction in the passing of steam around the elbow, attended by condensation and wet steam, will cause a loss of many times the cost above referred to every year that it is used; in other words, if the above line of piping carries steam produced by a coal bill of, say, $20 a day, every elbow will put a

tax on this amount of one per cent. at least in deterioration of the steam and loss of its effective pressure, and the man who pays this daily interest, although it seems a small matter, loses the large aggregate of £15 to £20 in a year.

The loss is still more pronounced with high-pressure steam, as the above figure is based on pressure as formerly used, about 85 pounds. When it comes to steam rushing through for the present high-speed engine with 250 pounds pressure, the eddy formed by the ordinary elbow is of the most damaging character. No data are to be had showing actual loss occasioned by the use of elbows with the latter pressure, although it is reasonable to suppose that it would be two or three times that with the lower pressure.

Proper appreciation of this would revolutionize all piping work, make the use of wrought bends universal, and restrict the use of elbows to only such cases where they are absolutely necessary. It would save large sums of money, counting the first cost only, as it is an indisputable fact that every elbow used costs two or three times as much as a bend would cost, providing it were possible to use a bend in the position that the elbow takes. As the demand for bends increases, they will cost less, and will ultimately be furnished, so far as the cost of the work is concerned, in standard sizes and radii at a cost of less than moulding and machining the present cast-iron elbow.

This statement, of course, has reference more especially to the larger size of piping, but even in hot water heating systems, sprinkler jobs, and small pipe work, frequent savings can be effected by the use of wrought bends instead of elbows, increasing the efficiency and circulation of the hot water or other system; and this is also true in conveying liquids generally.

On the other hand, with the lines of piping that are now up, and especially those in which the steam pressure has been increased, it is the judgment of the best engineering talent of the day that all elbows should be removed and well-made wrought bends substituted for them.

This reasoning is prompted by the additional fact that the old elbows are dangerous to all persons who work near them, as the expansion and contraction of the lines of piping on each side increases the strain beyond a reasonable factor of safety, and then it is only a matter of time when the fittings will break, with disastrous results to their surroundings.

Reports are frequent of bursting of lines of piping, with consequent property destruction and frequent loss of life. It will be found in nine cases out of ten where such accidents are reported that, in place of the pipe bursting, it has been the failure of an elbow or cast-iron flange, or something of that character on the pipe in place of the pipe itself and it is actually criminal to risk the life of men by leaving cast-iron elbows in a line of steam piping.

There are several features connected with pipe bends that are worth further consideration here. One of these is self-evident—that is that the larger the radius to which the pipe is bent the farther it reaches in the line; or, in other words, the already-mentioned piece of wrought pipe, bent on a centre radius of 80 inches, will go much farther around the corner to be passed than one bent on 40 inches, somewhat on the principal more fully described below.

Another lies in the fact that the larger radius, or about 8 times the nominal diameter of the pipe, is much easier to bend on than, say, 4 times the nominal diameter of the pipe, and while it is a very easy matter for a "smart young man" in the draughting room to take the shining instruments from his case and draw circles for the purpose of laying out a system of piping to be ordered, it is an altogether different thing to do this

with the view to designing the bends in such a manner and with such radii that they can be most easily made, and with a consequent saving to all concerned.

Another thing is the fact that if bends are ordered in random lengths at both ends, wherever they can be used in that way they will be a great saving to the maker as well as the user of the bend, as a piece of pipe can be easily formed into a bend, leaving the two arms of the square in exact lines to make any required degree, whatever it may be. This avoids waste of pipe and time in making the bend, and if this is to be used in a run of piping it is much less expensive to cut the straight pipe than it is to cut the bend after it is made, and the latter usually makes waste at both ends of the bend that someone has to pay for. This may be modified by making the bend to start at a fixed point at one end and let it come random at the other, which is much better than to have it come to fixed points at both ends. So far as the making of the bend is concerned, ordinarily from 8 sh. to 20 sh. can be saved on a large bend by observing the above statements.

Some persons advertise that they make very close-radius bends, but it is a mistake to do this in a general way for the two reasons above stated. With close-radius work, too, pipes will frequently break. Anyone can make bends to a very short radius if absolutely necessary and if they go about it right, yet no one can make them as cheaply as they can make those with a reasonably large radius. Even the people who are advertising as noted can do better work if the bends are made as stated, with a radius of 7 or 8 diameters of the pipe to be bent.

This brings us to the length of the pipe and also to the possibility of making large-radius bends with a single piece of pipe. Where this cannot be done, for instance, with expansion loops and expansion *U*-bends, it is much better practice to weld the pipe up to the required length, which can be done in almost any size nowadays, and thus avoid the making of joints which are liable to blow out.

It will be noted in Fig. 2 that welds in place of other joints can be adopted to most excellent advantage, especially in underground work, where it is possible to cut across lots to make deflections or angles of any character in laying down a line. Turning street corners can be done easily on a very large radius, preferably with the pipe bent somewhat similar to that shown in Fig. 2, saving trouble with joints, reducing the cost, and avoiding gray hairs generally.

The welds indicated in Fig. 2 can readily be made up to at least 16-inch pipe sizes, and as long timbers are shipped by railway, it is possible to ship pipe of this character, providing it is in sufficient quantities to warrant the preparation of cars for transporting it. Such pipe would undoubtedly meet more exacting requirements in a great many places

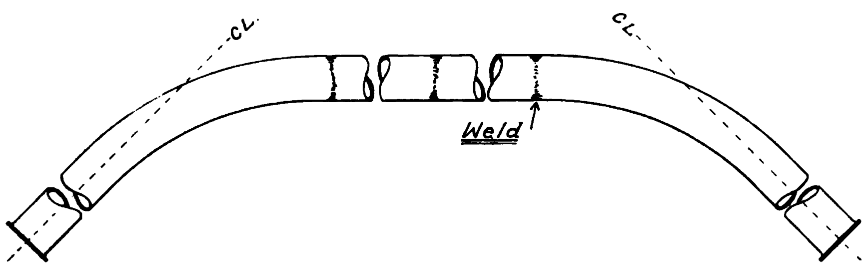


FIG. 2.—WELDS INSTEAD OF JOINTS IN PIPE BENDS

that now give a world of trouble with joints, even if the flanges are welded on, and the expense of welded flanges is, in the opinion of the writer, much higher than that of welding the pipe itself.

In Fig. 2 four pieces of pipe are welded together to make a length of about 80 feet, near the ends of which are made 45-degree bends, the two bends making a full quarter turn. If an ordinary elbow were to be used in place of these bends and carried to the apex of the centre lines, it would require more than 100 feet of pipe to go around the corner. This excellently illustrates the great saving to be made in using such work.

As to the making of joints, we have come to this by regular steps. There is every reason for doing away with screwed flanges, some of which allow us to mention. Cutting threads is a very uncertain thing with steel pipe so largely used, as the threads will break and tear off and give trouble in many ways, making the weakest point in the entire line in the threads themselves. The average cast-iron flange is screwed on the taper thread so forcibly that the wedge action of the thread will produce a strain on the flange, equalling, if not far exceeding, its safe limit of strength. When to this the steam pressure is added, pulling in the same direction, it is not remarkable that flanges break.

Another thing, it is about as expensive to cut threads, put on a flange and face it off as it is to flange the pipe out, as shown in Fig. 3, and, if properly made, the latter leaves the pipe in good condition and will make a joint that will stand more pressure than the body of the pipe itself.

This is not said in derogation of welded flanges; but the flanged-out portion of the pipe, reaching out to the bolt holes, gives just as much surface to carry packing as any flange does, and it is only a question of time when flanged-out joints and welded joints will be universal and will be furnished at less cost than the ordinary threaded pipe, so far as making completed joints are concerned.

I know that some persons are making the above class of flanged-out

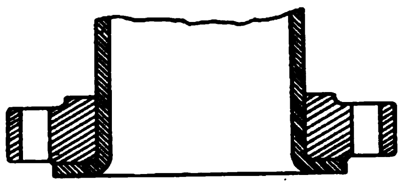


FIG. 3.—A GOOD FORM FOR A FLANGED JOINT

joints under high-sounding names, claiming them to be wholly of their own origination, and patented, and all that; but anybody can make them if they know how, and a thing as good as this is in an engineering

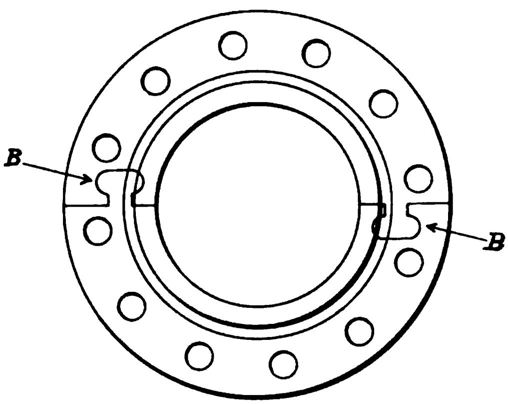


FIG. 4.—A DIVIDED FLANGE FOR A FLANGED-OUT JOINT

sense ought to come into universal use, or be demanded in every job where pipe larger than 4 inches is required, and become so common that it can be furnished at a much lower cost by reason of the increased demand and cheapened cost of production.

With the flanged-out joint it is best to use a divided flange, like that shown in Fig. 4, making a most convenient article to use, especially where it is difficult to get pipe into

position with the flanges over the same, as it will be noted that this flange can be put on a pipe after it is in place. It is simply locked together at *B B*, and the two flanges are bolted together so that the dividing lines cross each other, thus making companion flanges that are just as strong as though they were made solid. This obviates all trouble in connection with ordinary flanges placed over the pipe loosely before being flanged out, as such flanges slip back and forth and are very difficult to handle in erecting.

Another thing, if piping is to be put through a wall, the divided flange does away with the necessity of cutting a large hole through it to get the flanges through. The flanged-out part requires but a slightly larger opening than the pipe itself. The divided flange also is indispensable in very close quarters.

As above stated, this form of flange is made preferably of steel castings, and after it is bolted together, the strain is all removed from the tongue and groove, as the bolts hold them in position, removing the strain from the connections proper of the two parts.

One point in connection with the making of wrought bends that was omitted in its proper connection above is that in bending pipe, especially in larger sizes, it will nearly always show slight buckles on the inside of the bend; but in the opinion of the writer, it is better to have these left just as they come than to have the pipe bent in such a way as to stretch it unduly on the outside of the bend to obviate buckles. It is considered better practice to leave them without hammering them down, as steel pipe will not stand this usage very well. It is liable to cause slight fractures in the metal or produce a laminated condition, weakening it very materially.

If, in ordering bends, the above were mentioned so that the maker of the bends could leave the pipe without hammering, the user would get a much better and safer job, for the reasons above stated. Similarly, where it is possible to do so, the radius of the bends might well be left to the maker's judgment as to what the pipe will stand. If he is at all considerate of his own interests as well as those of his customer, he will make them of such character as will be best suited for the purpose, and, at the same time, at a price that will be a saving to the purchaser. Many other points of similar nature will probably occur to the reader in giving this matter attention.

THE NEW BRITISH BATTLESHIP "DREADNOUGHT"

THE LARGEST WARSHIP EVER BUILT

By a Staff Correspondent

NOT for many years has the building of a man-of-war excited such widespread interest as that of H. M. S. "Dreadnought." In many respects this ship has assumed a sensational character; she is the largest vessel ever constructed for any war fleet; she was the first to be commenced after the recent great struggle in the Far East; her design, which embodies many new features, has hitherto been kept an official secret, and the work of construction has been pressed forward with so much success that it is hoped she will be in commission within fourteen months of the laying of the keel plates.

All these facts have contributed to arouse curiosity, particularly as it is well known that British naval attaches were accorded special privileges by the Japanese and were enabled to watch the progress of the war to greater advantage than the representatives of other powers. Consequently, from the day when the first whispers of the coming of the "Dreadnought" were heard, an unusual amount of interest has been taken in this ship, not only in the United Kingdom, but in foreign countries, and the influence of the design may be traced in the new programmes of several rival Powers. Now that the shell of the "Dreadnought" is complete, the armour is in position, the engines and boilers have been fixed and the armament is being mounted, it is possible to give a more detailed description of the vessel than has hitherto been possible.

The essential feature of the "Dreadnought" which distinguishes her from all battleships now in commission in the world's fleets is that she is of huge size and mounts only one type of gun for use in line of battle, instead of three types, as in the "King Edward VII." class.

The war between Japan and Russia conclusively showed that the intermediate armament carried by vessels flying European flags was not effective at modern battle ranges. Even on the partial evidence obtained by the French authorities it has been calculated that the effective ranges for battle have been raised from 3000 yards to 7000 or 8000 yards.

Careful calculations show that at such a distance the striking power of 7.5-inch and 6-inch guns which have been the favourite intermediate weapons in the British Navy hitherto, are comparatively useless. The 6-inch weapon has no effect on armour at these ranges, while the 7.5-inch, though it strikes a heavier blow, is not able to inflict such damage as would penetrate even the armour plate of a first-class cruiser; consequently, in designing ships in accordance with the lessons of the war in the Far East, the naval authorities of the world have been led to debate the relative advantages of the 9.2-inch, the 10-inch, and the 12-inch guns.

Prior to the war Great Britain was mounting in each of the "King Edward VII." class four 12-inch and four 9.2-inch guns, but since the battle of Tshushima, which was won mainly by the gun fire of the heaviest weapons carried by the Japanese battleships, opinion has gone in favour

of the 12-inch weapon, though in France, on less complete information, the authorities have decided to retain the 10-inch gun in view of the economy in weight thus effected. The British Admiralty, however, in drawing up the design of the "Dreadnought," determined that simplicity of armament, leading to simplicity in construction and ample protection of ammunition supply and hull, was of the greatest possible importance, and consequently in the design of the "Dreadnought" they have realized the ideal of Admiral Bienaime, formerly chief of the French staff, and have designed the ship with "one type of gun and one type of projectile only."

It is understood that originally the "Dreadnought" was to have carried twelve guns of the 12-inch type, but difficulties arose in working out the design, and it was eventually decided to drop out two of these weapons in order to mount effectively ten pieces of this colossal striking power, so as to enable eight of them to fire on the broadside, six ahead and four astern, without endangering either the stability of the ship or running any undue risks owing to the "blast," which, in the case of the "Lord Nelson" and "Agamemnon," it is now realized, will prevent a full broadside, as originally planned, being employed.

The armament of the "Dreadnought" has encountered some criticism on account of the comparative slowness of fire of the 12-inch gun in comparison with the rapidity which can be obtained by the 7.5-inch and 6-inch weapons. With the best gun crew the 12-inch gun or the 9.2-inch gun can fire only about two rounds a minute, while the 7.5-inch weapon may discharge as many as three or four, and the 6-inch gun may discharge in the same unit of time as many as eight projectiles. It has been urged that though the smaller guns may not be able to pierce the armour plates of battleship or cruiser at modern ranges, the effect of a series of 100-pound shells falling on a ship is of great value in demoralizing a foe, driving the crew from exposed positions and bringing down top hamper of one kind and another, thus frequently setting up local fires.

On the other hand, it is urged that the rapidity of fire claimed for the smaller guns is largely imaginary at the range which will obtain in future battles. Owing to the limited supply of ammunition which can be carried in a modern man-of-war, the greatest care has to be exercised in aiming each shot, and thus, unless a waste of shell is to occur, the flight of each shell must be carefully watched, with a view to correcting the range before another is discharged. This operation of watching each shell find its billet severely limits the rapidity of fire, however efficient any individual gun may be, and experienced artillerists claim that in battle action not more than two shells a minute can be fired from any one gun with any hope of making good firing.

Under these circumstances the advantage of the 6-inch and 7.5-inch weapons disappears, while, on the other hand, the difference between the striking power of secondary and primary weapons is so great as to leave no doubt in the minds of British naval officers as to the unwisdom of devoting weight to any gun of less power than the 12-inch weapon, which is regarded by British authorities as the smallest big piece which can be employed in line of battle with maximum power.

The 12-inch gun which is to be mounted in the "Dreadnought" is not, however, the weapon hitherto carried by British men-of-war. In velocity the 9.2-inch gun "Mark X.," carried by the "King Edward VII." class and the "Lord Nelson" and "Agamemnon" is superior to the "Mark IX." 12-inch gun, and consequently experimental artillerists in Great Britain have been busy for many months past producing a big weapon of increased power. As a

THE OLD "DREADNOUGHT" OF THIRTY ONE YEARS AGO. A VIEW TAKEN AT HIS MAJESTY'S CORONATION REVIEW AT SPITHEAD IN 1902. NOW ON THE LIST OF VESSELS FOR SUBSIDIARY SERVICE. DISPLACEMENT, 10,820 TONS. SPEED, 13 KNOTS. COST £600,000. SHE CARRIES FOUR 12.5-INCH MUZZLE LOADERS IN TWO TURRETS AND EIGHTEEN SMALL QUICK FIRERS

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THE NEW "DREADNOUGHT" AFTER LAUNCHING AT PORTSMOUTH DOCKYARD. DISPLACEMENT, 18,000 TONS. SPEED, 21 KNOTS. COST £1,797,497. ARMAMENT, TEN 12-INCH GUNS, TWENTY 12-POUNDERS, AND FIVE SUBMERGED TORPEDO TUBES. SHE WILL HAVE FOUR PROPELLERS DRIVEN BY PARSONS TURBINES

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result of long experiment a 12-inch weapon of 45 calibre has been evolved, which is claimed to be the best yet constructed for use afloat

The progress made with the 12-inch gun since it was first adopted in place of the 13.25-inch piece has been very rapid, and in view of the weight of the British shell, it is claimed that the weapon which is being put into the "Dreadnought" is even better than the gun of similar character, though lighter weight, which was adopted by the French in 1902. The progress in the construction of 12-inch guns in the United Kingdom and in France is set forth below:—

Nation.	Nature of Gun.	Weight of Gun in Tons.	Weight of Projectile. (lb.)	Muzzle Velocity. Foot-Secs.	Muzzle Energy. Foot-Tons.	Energy Per Ton of Gun.
British...............	12 in. Mark VII.	46	714	1914	18,136	394
	12 in. Mark VIII.	46	850	2367	33,032	718
	12 in. Mark IX.	50	850	2481	36,280	724
	12 in. (Dreadnought)	58	850	2900	49,568	854
French..............	12 in. 1893.	45.9	643	2625	30,750	670
	12 in. 1896.	44.4	750	2650	36,782	830
	12 in. 1902.	50	750	2870	42,890	858

It may be noted that the newest 12-inch gun of the British Navy, though it fires the same weight of projectile as the gun which is being mounted in the American ships of the "Connecticut" and "New Hampshire" classes, does not attain quite as high a velocity by about 100 foot-seconds. Although it is improbable that the Admiralty will countenance any further addition to the length of the 12-inch gun, which is already regarded by many officers as excessive, no doubt is entertained that further experiments will be made in the hope of evolving an even more powerful piece of artillery.

The new 12-inch gun, like all of those mounted in recent British ships, has been built on the wire system, the advantage of which is held to be so considerable in Great Britain in assuring the strength and soundness of material as to outweigh all the advantages which have been urged by foreign gun manufacturers. Many early 12-inch guns built on the wire system, it is true, gave some trouble, but the newest weapons are being made with a "shoulder" so as to prevent the inner tube from slipping forward under the great pressure to which it is subjected, and increased care is being exercised in the testing of material.

The principle adopted in the design of the "Dreadnought" has been to construct five entirely separate redoubts, each carrying a revolving turret fitted for two 12-inch guns. Each of these circular redoubts will be heavily armoured for their full length, and for fighting purposes will be entirely distinct. In fact, the "Dreadnought" will consist of five fortresses, each independent in its mechanical arrangements, ammunition supply, and gun crew. Around these five fortresses the ship has been constructed in such a way as to place two of the 12-inch guns on the forecastle 28 feet above the water-line, two redoubts in the after part of the ship, and two others on the broadside. The effect of this arrangement is to keep six of the ten guns on the centre line, but the arrangement has the disadvantage of causing two of the guns to be masked for fire astern. The "Dreadnought," however, has not been built to run away.

The "Dreadnought" is the first battleship without a ram constructed for the British Navy since the battle of Lissa, in 1866. The British Admiralty has finally decided that no British captain would ever think of employing such a weapon, in view of the danger which any ship incurs when it rams full-tilt at a foe. The bow of the "Dreadnought," in view of the elimination of the ram, has been greatly strengthened, and the ship is provided with an armour belt running practically its full length, and varying in thickness from 6 to

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11 inches. This belt is carried some distance below the water and rises very high, to give ample protection to all the vital parts, and an armour deck is provided of a thickness of 2 inches. It turns out that there was no truth in the statement that the "Dreadnought" would not carry torpedoes. As a matter of fact, she will have five submerged tubes.

In view of the experiences of the war between Japan and Russia, special attention has been devoted to the construction of the hull and to the security of the shell rooms and the magazines. For the first time in any British ship the bulkheads have not been pierced by doors. Hitherto it has been the custom to fit water-tight doors, manipulated by hand power. From time to time experiments have been made with various mechanical arrangements for closing these doors instantly in case of accident, but the British naval authorities have time and again rejected all inventions and have persisted in the old system which proved so defective when the "Camperdown" rammed the "Victoria" off Tripoli, in 1893,

with such disastrous loss of life.

In the "Dreadnought," however, there is no communication of any kind between the several compartments; but in order to minimize the inconvenience thus caused, lifts have been constructed and officers and men in one compartment who desire to pass to another in the course of their duties will, it is contended, be able to do so with little loss of time and at very slight inconvenience in comparison with the great advantage due to the invulnerability of the bulkheads.

An unusual amount of attention has also been devoted to the construction of the bottom of the "Dreadnought," with a view to minimizing the effects of mine explosions. The Russo-Japanese war, however, showed that the greatest danger was to be anticipated from attack not directly at the bottom of the ship, but at the sides, and it is in view of these lessons that the British Admiralty have incorporated in the "Dreadnought" a number of special precautions with a view to localizing the effect of an attack by mines or torpedo, while at the same time the magazine and shell rooms have been placed as far as possible from the skin of the ship and have been provided with armour protection. In view of these arrangements, it is contended that although the "Dreadnought" might be seriously endangered by a mine explosion under the very elaborate cellular bottom, the detonation of a torpedo or surface mine at her side would not have serious effects.

As a result of the successful installation of the Parsons turbine in many passenger ships, and latterly in the liners of the Canadian Pacific Railway Company and the Cunard Steamship Company, the Admiralty determined to adopt this form of propulsion for the "Dreadnought." The ship has been designed for turbines calculated to propel her at the rate of 21 knots an hour, which is two knots more than the speed of any existing British battleship. There are to be two high-pressure turbines and two low-pressure and four propellers. Model experiments have shown that this equipment will propel the "Dreadnought" at this high speed with less vibration than is experienced in existing battleships with a legend rate of steaming of 18 or 19 knots, while at the same time the astern turbines will give to the vessel a stopping power not much inferior to that obtained in battleships dependent upon reciprocating engines.

In settling the lines of the "Dreadnought," great care was exercised by Sir Philip Watts, Director of Naval Construction, to obtain a hull which would be extremely handy in evolutions. The stern of the "Dreadnought" is probably more cut away than that of any big ship hitherto launched, and naval officers who have seen the vessel in dock entertain sanguine expectations that, in spite of her great size,—she displaces nearly 18,000 tons,—she will prove the handiest battleship in the British fleets.

In working out the design, Sir Philip Watts evidently kept in view the present docking facilities in various parts of the British Empire, and constructed a ship which can be accommodated in any of the large docks at the great British naval stations. One of the grave defects of many battleships built in the nineties for the British Navy was that the draught was so great that even the "Victorious," outward bound to China, could not pass through the Suez Canal without lightening. In the "Dreadnought" every effort has been made to keep down the draught to reasonable limits, and the extra displacement has been absorbed in the length and beam, so that the vessel can pass through the Suez Canal with complete ease.

The advantages associated with the design of the new ship are many, apart from the concentration of fire from her ten 12-inch guns. Owing

to the elimination of the medium armament, it has been possible to provide for the guns, shell rooms, and the magazines, as well as for the supply arrangements far more adequate protection than has hitherto been found practicable. The simplification of armament has led to the reduction in the weight of spare parts, and to the installation of a more simple and effective method of fire control from a high platform on the ship's one mast than is to be found in existing British men-of-war which have been encumbered with a variety of guns. At the same time, the adoption of the Parsons turbine has enabled engine rooms to be produced which are probably the most convenient and roomy ever seen in a man-of-war.

Furthermore, the simplicity of the fighting arrangements and the increased reliance which is being put in mechanical arrangements has resulted in a great reduction of the personnel. The complement of the "Dreadnought" of 18,000 tons will be far smaller than that of any battleship now serving in the British fleets, and this will react upon the costs of upkeep, which, it is calculated, will be far less in comparison with previous ships with their more complicated design, variety of guns, and multiplicity of spare parts for the reciprocating engine.

Another outcome of the simplification of the design of this battleship has been the rearrangement of the quarters for the officers and men. The admiral, captain, and commissioned officers, instead of being at the after parts of the ship, whereas their work is mainly forward, will in future have their cabins and mess rooms almost directly under the forward and only bridge, so as to be conveniently near the scene of their duties. The disadvantage of the old arrangements, whereby the wardroom of the officers and the cabins of the captains and admiral were in the after part of the ship, were so considerable that it had become the custom of officers commanding fleets and ships to have special cabins constructed for their use when at sea, and the ordinary accommodation in the after part of the ship had come to be regarded as largely ceremonial.

The Admiralty also have abandoned the small round port hole which has been fitted in British ships for many years past, with its minimum admission of light and air. The "Dreadnought" has been fitted with windows as large as those which are to be seen in any ordinary house, and no doubt is entertained that this innovation will tend to promote the health and comfort of officers and men. This is an innovation which, on a small scale, was tried with excellent results in the Russian battleship "Retvisan," which was built by Messrs. Cramp & Co., of Philadelphia, afterwards to fall into the hands of the Japanese during the late war. In this vessel, for the first time, an effort was made to remodel the accommodation for officers, and the commander and captain were given apartments flooded with light and air and far more ample in size than had hitherto been seen on board men-of-war. The "Dreadnought" approximates to American-built ships in respect to the arrangements made for the comfort of the men of the lower deck.

The best possible systems for heating and ventilating the vessel between decks have been incorporated in this latest accession to the British fleet, and space has been found for installing a commodious bakery so as to enable the crew to be provided with bread at all times when at sea in place of the "hard tack" which has hitherto been served out in British ships when from port.

In cost, the "Dreadnought" will be one of the cheapest battleships built for many years past. It is true that her namesake of thirty years ago represented an outlay of only £600,000, but she was a small ship of only 10,820 tons displacement, and her armament comprised only

four 12.5-inch muzzle-loaders, mounted in two turrets, apart from eighteen very small quick-firers. Besides her ten 12-inch guns, the new "Dreadnought" carries twenty 12-pounders of a new and powerful type for defence against torpedo craft. The old "Dreadnought" had a nominal speed of about 13 knots, whereas the new vessel is expected to attain a rate of over 21 knots, with a radius of action sufficient to carry her across the Atlantic and back again.

With a broadside of eight 12-inch guns, the "Dreadnought" is equivalent to any two battleships built for the British fleet prior to the construction of the "King Edward VII.," and yet her total cost, complete with guns, will be only £1,797,497, while the ships of the "King Edward VII." class, carrying only four 12-inch guns and the same number of 9.2-inch guns, represent an outlay of just under a million and a half sterling.

In view of these facts, there is excuse for the claim which has been made by admirers of the "Dreadnought" design that she is not only the largest and most powerful ship hitherto put into water, but she is also the cheapest. The fact that she has been constructed in so short a time is a matter of small importance, because it has been entirely due to exceptional circumstances and quite exceptional effort. Representing, as she does, a new design in many important particulars, the Admiralty determined to spare no effort to put her through her trials before this particular type of ship had been reproduced; consequently elaborate and, as events have shown, successful arrangements were made to maintain the necessary supply of material as the vessel progressed, and a large amount of overtime has been worked from the first by the artisans at Portsmouth Dockyard. In view of the special and expensive measures which have been taken to expedite the construction of the ship, her comparative cheapness is all the more remarkable.

THE METRIC SYSTEM FALLACY

ANTI-METRIC OPINIONS FROM LEADING AMERICAN ENGINEERS AND MANUFACTURERS.

IN connection with what was printed under the above head in the May number of this magazine, the following additional anti-metric opinions make interesting reading, all of them emphasizing the stand against the compulsory adoption of the metric system, taken by manufacturing interests, large and small.

There is scarcely a dissenting voice among all those with whom this magazine has been in correspondence. Oberlin Smith, one of the contributors to this series of short articles, it is true, starts off in prometric vein and says some good things of the metric system; still they are the things which many others also are ready to admit, but which count for so little in the final summing up. Mr. Smith, himself, is withal firmly opposed to the metric system.

That the electric industries are not in favour of this system,—a point made in these pages last month,—is excellently demonstrated by the declaration of the Westinghouse Company, represented by W. M. McFarland, its acting vice-president. Mr. McFarland says that the alleged superiority of the metric system for electrical calculations is not a fact in their work, and the Westinghouse Company's designers not only do not use, but do not want it. This declaration is to be particularly commended to the attention of those who still harbour the pet delusion that the electrical engineer is a metric advocate.—The Editor.

From William Kent, Dean of the College of Applied Science, Syracuse University

THE renewed agitation during the past two years in favour of the adoption of the metric system has resulted in the establishment of two facts:—First, that the English system is so thoroughly incorporated into the language, literature, habits, and customs of the English-speaking race, that it is impossible for it ever to be displaced as long as the English language endures. Second, that there is the continual danger due to the intense activity and eloquence of the advocates of the metric system that they may get laws passed compelling its introduction in the government service. The use of one system by the government and another by the people would lead to no end of confusion. The question now before Congress and the people is not as to the relative merits of one system over the other, but as to whether the United States is to have two systems existing side by side. The American Society of Mechanical Engineers has just published a report of the Committee on "Standard Proportions for Machine Screws." It contains several very elaborate tables in the English system, divided decimally, and the committee has spent a great deal of time and labour in working out the system to the utmost refinement. It will be adopted by every manufacturer of machine screws, and by every machine shop in the United States that makes or uses such screws. Anyone who thinks that this system of screw heads, so

carefully standarized and so generally adopted, can ever be replaced by a metric system, in which the number of threads is not given as so many per inch of length, or as so many in any unit of length whatever, but in which the pitch is given in millimeters and decimals of a millimeter, must be unfamiliar with machine shop practice.

These machine-screw standards, together with the Sellers standards for larger bolts, and the standards of pipe, pipe threads, and pipe flanges, can never be replaced by metric standards, and if the metric standard should be adopted at any time, we would have the confusion of two standards, instead of one.

The arguments in favour of the metric system are practically the same as they were thirty years ago. No progress whatever has been made in the introduction of the metric system into the United States in that time, in the mechanical trades, but there has been a tremendous increase in the argument against it. In the increase of population and wealth, the growth of the manufacturing industries and the increasing number of people engaged in them, all using the English system, have increased the difficulty of making the change from the English to the metric system, so that it is practically impossible.

The literature on the anti-metric side is increasing rapidly. Halsey & Dale's book and the bipartisan report in the transactions of the American Society of Mechanical Engineers, Vol. XXIV., and also the pamphlet reports of recent arguments before the Committee on Coinage, Weights and Measures, furnish an amount of ammunition which, when properly used, will overwhelm the advocates of the metric system. Other matter will be found in the report of the Committee on Coinage, Weights and Measures, published in 1879, Report No. 14, House of Representatives, 46th Congress, first session. It was the study of this report, twenty-five years ago, that converted me from being a believer in the metric system to a staunch advocate of the English system, and led me to use the following words in a paper on the metric system which I read before the Engineers' Society of Western Pennsylvania, in 1880:—

"Yes, first establish an international money system, successfully accomplish the reform in the spelling of the English language, teach all the nations of the earth to speak one universal language, or do any other desirable, but herculean, labour, which finds its chief hindrance in the habits, traditions, and prejudices of millions of the human race, and you may be prepared to undertake such a revolution as would be the substitution of the meter for the two-foot rule."

From W. M. McFarland, Acting Vice-President of the Westinghouse Electric & Manufacturing Company, Pittsburg

WRITING to Hon. J. H. Southard, chairman of the Committee on Coinage, Weights and Measures, Mr. McFarland says:—

On behalf of the Westinghouse Electric & Manufacturing Company, and as voicing the wishes of its management, I desire to enter an earnest protest against the bill for the compulsory use of the metric system by the departments of the government, and respectfully urge that your committee report the same unfavourably,* for the following reasons:—

(1) It is an insidious and disin-

*It is pleasing to be able to state that, immediately previous to going to press with this issue, the House Coinage Committee voted not to report the bill favourably.—The Editor.

genuous method of forcing the metric system upon the country generally.

The relations of the various branches of the government to industry and manufacturing are so numerous and so close that, if these departments must use the metric system, it will compel manufacturers to shift over entirely to the new method, shift over in part, or cease to do business with the government departments.

Firms whose main output goes to the government, like some of the shipbuilders, will be forced into the new system, for it is obviously impossible that they should use one system and the government another.

Where government work forms only a part of the output of a firm, it might set apart a portion of the works and equip for the new system, or it could cease to bid for contracts with the government. The former means an unnecessary increase in expense. The latter is an alternative which is hardly consistent with the avowed desire of the government to secure wide competition.

The foregoing is cited to show that manufacturers have a vital interest in the bill, even though its wording is evidently meant to convey the idea that only the government departments will be affected.

In brief, the government is not a manufacturer (except for a very few things) and, therefore, must buy from those who do manufacture, so that the bill affects them just as directly as if they were explicitly included in its wording.

(2) The introduction of the metric system will produce no benefit whatever to my company and most other manufacturers, and will cause us actual loss in money and time, a reduction of efficiency for a considerable period, and great annoyance and confusion.

(3) The alleged superiority of the metric system for calculation is not a fact in our work. We use the inch with its decimal multiples and sub-multiples in calculations, so that the two systems are equal.

(4) Persons who do not know the details of the electric industry have stated that it is so tied up to the metric system that it would confer great advantage to adopt it. This is not true. Some units are natural constants, and the others can be defined just as easily and exactly in English as in metric units.

Our designers say that the use of the metric system would confer no advantages, and it would, for a time, cause delay while they were getting accustomed to it. All our records are in English units, and these would have to be recalculated into metric units, causing loss of time and considerable expense.

(5) The cost to us of making the change would be in the neighbourhood of a million dollars. Four years ago, I gave figures of over half a million. Our works have grown in the meanwhile, and the cost of the change would now be much greater.

This cost is made up of the substitution of new patterns, dies, jigs, templates, scales and measuring devices in the shop, and of new drawings. These would be necessary, because it would be impossible to use the existing ones for metric measure, on account of the incommensurable ratio between the meter and the inch.

When work is laid out, the dimensions are always such as come on exact divisions of the scale. As the metric and English scales do not coincide anywhere, the existing English measurements would not come to any division of the metric scale, thus involving inaccurate work and unsatisfactory machinery. If it be said, why not use verniers and micrometers, the answer is that this means increased time and cost.

(6) There would also be the increased expense of maintaining part of the works on the old system, to supply repair parts.

The committee has been favoured with opinions by those who were

avowedly ignorant, because not in a position to know, to the effect that the opponents of the metric system have greatly exaggerated this feature. Your earnest attention is called to a few facts, as follows:—

There are now in use, and rendering good service, over 3000 railway motors, which we built from 1892 to 1895, and for which we daily get orders to supply repair parts.

The first of the great generators at Niagara Falls were supplied over ten years ago, and they will be used for many years yet.

There are thousands of motors and generators of various types, which we built from five to ten years ago, which will be efficient for years to come, and for which we are constantly supplying repair parts. This simply means that certain parts naturally wear out in use and, when replaced, make the machine as good as ever. The "repair part" business of my company amounts to about a million dollars a year. This is not surprising when it is known that the total output to date is valued at about two hundred million dollars.

These are facts, based on an inspection of our records. In view of such facts, the airy way in which ignorant persons attempt to dispose of the subject is outrageous.

(7) The efficiency of all who use measurements in calculation, designing, draughting, and manufacture would be seriously impaired for a time.

It is easy to prove this yourselves by testing persons who claim some familiarity with the metric system, but do not use it habitually. It will be found that they really think in the English system and translate to metric. When it comes to compound units, such as pressures or strengths as related to areas, it takes a long time to get any realizing sense of values in the new system.

(8) Study of the printed testimony before the committee shows that, with few exceptions, those who advocate the adoption of the metric system are men who have nothing whatever to do with making things, but only with measuring them after they are made. There is an enormous difference between the two cases. Their measurements are made for purposes of calculation, and any decimally divided scale is convenient.

It must not be thought that the essence of the metric system is decimal division. Its essence is the constant ratio. It happens to be ten, but the real good features of the system would be the same if the ratio were eight or twelve. Many think they would be greater.

A distinguished chemist commented on my testimony four years ago, that my statement about the incommensurable ratio of the units preventing the working to exact sizes was the weakest argument he had ever heard. That was only because he was ignorant of manufacturing. Any one skilled in shop methods would tell you just what I did.

(9) Manufacturers do not object to anybody using the metric system who may find it more convenient. Perhaps chemists do. We do object most strongly, however, to having chemists, astronomers, and others, who know absolutely nothing of the details of manufacturing, try to dictate to us how to run our business. We believe also that, under the simplest rules of evidence, they should not be allowed to express opinions about our line of work. Their earned reputation in other lines has a tendency to give weight to their erroneous opinions unless contradicted.

The printed testimony shows that manufacturers, as a rule, have told what they know, while the scientists have been allowed to tell what they think, which, as affecting lines other than their own, has generally been entirely wrong.

(10) To abandon the inch for the millimeter means the giving up of many standards of the highest value, such as threads for bolts and nuts, and for pipes, with nothing to replace them. My testimony of four

years ago goes into this at length.

(11) The claim is made that we now have a great confusion of units and ratios, all of which will be removed by adopting the metric system.

To this the answer can be made, with absolute certainty, that such will not be the case. We shall simply add the metric units to the others. This has been the history of France and Germany, in the former of which the metric system has been in use over a hundred years.

This talk about confusion really comes from a confusion of ideas, and a lack of understanding of the object of varying units. The fact is that each trade or business uses the unit which is most convenient to it.

Manufacturers of machinery have really only one unit,—the inch. Everything else comes from it. Builders use the foot and inch. Others find the mile a convenient unit. Astronomers find for some purposes that a "light-year" is a useful unit. We have no objection.

There is no reason why the factories which make cloth should use the same unit as those which make machines.

(12) For about forty years, it has been legal in America for any one who so desires to use the metric system. Why has it made so little progress, if it has such advantages as its friends claim?

Manufacturers have shown again and again that they are ready to abandon old methods and adopt new ones, even at great expense, when there is some benefit in doing so. A vast number of the responsible men in our great factories are technically educated men, who have used the metric system at college, and have had a chance to test it.

If it had any real advantage, they could, through the great engineering societies, easily agree upon its adoption.

Please note that the American Society of Mechanical Engineers, after an elaborate consideration and discussion of a report, which gave both sides of the case in great detail, voted by letter ballot against the adoption of the metric system by a ratio of 3.6 to 1.

In conclusion, it is respectfully submitted that the arguments against the compulsory adoption of the metric system are so strong as to be convincing.

This bill is an attempt of pure scientists, to whom the matter is not vital, but, at most, a choice between two good systems, to force upon people to whom it is a vital matter a system which, after thorough investigation, they do not want, and which would cause them annoyance, expense and inefficiency in their business.

From James Hartness, President of the Jones & Lamson Machine Company, Flat Turret Lathes and Equipments, Springfield, Vt.

THROUGH all this discussion, too little consideration has been given to the man who works. Directions should come to the worker in the most readily understood terms, and should not require translation by a foreman. Workers are annoyed and hindered by any uncertainty about directions.

Of course, it is desirable to facilitate the work of engineers and other directors of the grand schemes, but this should not be done at the expense of greater total cost of work. Metric advocates should remember that the worker is frequently taxed to the limit of physical endurance, and that, no matter how great is his mental endowment, he is in no condition when working to translate a decimal into a natural dimension.

These workers, as a class, are not writers or talkers, and some are not even readers of technical subjects: nevertheless, this subject should not be settled without a most serious

consideration of these men. The adoption of any system that requires an increase of mental effort on the part of the worker bars progress, by making directions incomprehensible to those of lowest mental endowment, and a serious hinderance to action of the higher type.

From Oberlin Smith, President of the Ferracute Machine Company, Sheet Metal Tools, Bridgeton, N. J.

REGARDING the metric system, there is no question that with it most calculations necessary are vastly easier than with any other system—all multiplication and division required for translating from one denomination to another being performed by sliding decimal points to the right or left, as occasion demands. This is notably shown by comparing the ease with which we calculate American money and English money, respectively. In cases where one kind of measurement is combined with another, as long-measure with square or cubic-measure, or with liquid-measure, or with weights, there is ofttimes a large saving in calculation, on account of the arbitrary relation between the different units which have been purposely, and properly, embodied as so many cubic centimeters to a litre, etc.

In taking measurements, the metric system has no special advantage or disadvantage, as the operation is performed with special tools of little cost, such as graduated rules, cup-like utensils, scale-weights and beams, etc. In recording measurements, the metric system is in many cases the most convenient of any, as all fractions are expressed decimally. Theoretically considered, the metric system is beautiful in design and almost perfectly logical.

In opposing, as I do, the general introduction of the metric system in America, I consider it but fair to admit, as above stated, that the metric system is better in principle than ours, and that if we were starting afresh upon a new planet it would be wise to adopt it,—if we had nothing better. The necessity for a strong fight against the proposed change is, to my mind, confined chiefly to measurements of length, with their derived units for surface and for cubic capacity. This is not because of calculation (which would be easier with a decimal system), nor because there is any difficulty in taking measurements with a tape-line or rule or micrometer made by a Frenchman. The great and crying evil would be not even in the act of recording these measurements upon millions of drawings in the factory and land offices of the country, but it would lie in the horrible array of decimals which would be necessary to express our present measurements, which have become standardized.

The draughtsman and machinist would have to write of and speak of a 15-16-inch gauge or mandrel, or reamer, as of 23.8125 mm. diameter, or of a $1\frac{1}{4}$-inch bar of iron as a 31.7501 mm. bar. The carpenter would designate his 3×4 scantling as 76.2×100.16. Some small decimals he might drop off, but most of them would remain,—especially in machine shop work. The conveyancer and land-owner and lawyer, in speaking and writing of a 20-foot lot, and making records of the same, would have to mention it as measuring 6.096 metres in width, or of a 50-foot lot as being a 15.24-metre piece of property.

I will not here attempt to give other instances of the wonderful figures that would appear in describing the present standard sizes of the uncounted millions of nails, screws, bars, pipes, shafts, pulleys, gauges, drills, taps, reamers, jigs, and other

tools, not to speak of boards, scantling, timbers, bricks, structural metal, etc., as well as real estate of all kinds, which is now usually described in terms of acreage, or by feet and inches, or feet and tenths. These are but a few instances in practical life. We should soon find innumerable other cases where the only way to describe articles at present standardized would be by the use of a new language of measurements, expressed in numerous decimals.

The above-mentioned difficulties are based upon the assumption that we keep the tools, if not all our manufactured articles, to present standards. The other horn of the dilemma would consist in abandoning all these tools, perhaps more or less gradually, and substituting for them new ones, the principal sizes of which would be designated in certain round-numbers of millimetres or centimetres etc. This, of course, would make the reading and recording easy, but it would mean a loss of uncounted billions of dollars to the manufacturing establishments of the country. Not only would complete new sets of tools have to be designed and made, but the manufactured articles which are the products of these tools would have to be changed, together with all their drawings and patterns. Not only would this expense be entirely prohibitive and put many concerns into bankruptcy, but the new products would not have their parts interchangeable with the old ones, which would be an enormous inconvenience and expense to the people who used them.

In the case of land, it would, of course, be impracticable to change the size of most of the farms and building lots now measured off and held by definite ownership. Their dimensions would, therefore, have to be forever known by the use of trickling streams of decimal fractions.

To those who believe, as I do, in the rapid progress of the world toward more perfect methods, it may seem strange to oppose an advance from a bad to a better system, once for all, in spite of its difficulties. Were there no still better system looming up in the future than the two in question, I would say adopt the metric, in spite of the trouble and expense, and in spite of the fact that it is founded upon the decimal system, which has the foolish number 10 as its base.

The greater change above alluded to, and one which it seems to me and others is bound to come with the advance of the world's civilization, is the change of the base of our numeration from ten to sixteen. Although the number 10 seems so beautiful in calculation, it has no especial merit in itself, as any other number would do just as well, and be as beautiful, if only it happened to be expressed with a unit followed by a cypher.

The Arabic base 10 doubtless grew up in ages long past from the accident of a man having ten fingers, and his using them to count with. If he had had sixteen we doubtless should have been blest through all these centuries with a lot of numbers which would have saved an enormous amount of calculation and a good deal of writing and printing, as connected with mathematical tables, etc. If we should add six more digits to our notation, which any intelligent person could commit to memory in a few hours, and were to express the new base sixteen as we now write ten, then we could write any number up to 255 with one or two digits instead of mostly three. Any number up to 4095 would be expressed with one, two, or three digits instead of mostly four, etc.

The great advantage of this system, however, would be that the base number would be capable of binary division down to unity. It would also be convenient as a perfect square, a perfect fourth-power and double a perfect cube. Of course, 8 or 32 might make con-

venient bases for our numeration, but the first is too small and the latter too large, with too many digits to remember.

We all know the tendency of the human race toward binary division, and the convenience of it in all commerce and trade, as well as in working up various "scales" in draughting work. Witness the grocer, with his bushels, pecks, quarts, etc.; also the convenient division of gallons down even to gills, and of avoirdupois pounds down to ounces. Witness, further, the division of flexible articles by folding and refolding,—always by halves, quarters, etc., never by thirds or fifths or tenths. Who does not know the convenience and the naturalness of binary division and the inconvenience of trying to divide from 10 down in this way, and the troublesome fractions that occur thereby.

Firmly believing that at some future time this radical, but grand and splendid, reform will come to pass in the mathematics of the world, notwithstanding the numerous temporary difficulties of the change, I advocate putting up with our present English measures of length until the greater and better change can be made,—and who knows but one of the new units may be our beloved old inch. This grand reform can hardly come during the lifetime of him who writes this prophesy, nor of many who read it. Its prospective sometime advent is why I, with doubtless many others of like optimistic temperament, oppose botching the whole matter by making two tremendous changes instead of one.

The practical method of bringing the great change about will, perhaps, be to institute an international scientific commission, working under the auspices of all civilized governments during a term of years, making a careful study of the whole subject and designing a scheme for universal public use. This scheme would not be so difficult to learn as a new language. It should be taught everywhere to children in the schools, as a special study. The new methods could, in a tentative way, be applied to matters of commerce and industry by the students themselves to an extent that would make them love it for its logical simplicity. In a dozen years the growing generation would be ready for its more universal adoption. If the world at large was ready, so much the better; if not, the new science of measurement would remain on hand, in waiting for a more or less complete adoption, as the civilization of the various nations advanced to the proper stage.

From Robert C. McKinney, President of the Niles-Bement-Pond Company, Machine Tools, New York

I THINK the consensus of opinion in our own works regarding this matter is about as follows:—

1.—We believe that it would be extremely difficult to introduce throughout all branches of industry in the United States the uniform use of the metric system, and that this could be accomplished only at a great expense and by intelligent effort extending over a period of about twenty years.

2.—With respect to engineering practice, we believe that the metric system can be used by those entirely familiar with it with greater facility than can the English system, but the period of introduction should extend over a series of years, in order that the great masses of our workers may become entirely familiar with the new standard and be able to think in it, and not go through the double operations of making calculations in the English system and then translate them into terms of the metric system.

3.—In our own works it would be

entirely impracticable to change the dimensions of our existing machines, owing to the fact that we have hundreds of thousands of dollars invested in manufacturing equipment, consisting of special tools, fixtures and gauges for producing interchangeably the component parts of our machines, which would be a total loss if radical changes in dimensions were to be made.

It is true that our drawings could be remarked with metric dimensions which would be exact equivalents of the existing English measurements, with the important exceptions of standard pitches of screw threads and pitches of gears; but this would result in a series of decimals much less convenient of consideration than the present English figures. It would, however, be impracticable to make such changes in dimensions at this time, owing to the fact that many of our workmen are unfamiliar with the metric system, and costly errors would unavoidably result.

All new designs could be made to conform to the metric system. The most important objections to doing this would be, first, the unfamiliarity of our workmen with the metric system, which we do not consider extremely important; secondly, the very considerable expense to our individual workmen and to ourselves in obtaining a full working equipment of metric measuring instruments; and thirdly, the very considerable initial expense of supplying a general factory equipment of tools, such as taps, dies, reamers, etc., made to the metric standard.

4.—Whereas, as will be noted from the foregoing, we do not consider that there would be unsurmountable difficulties to be overcome in the gradual introduction of the metric system into our own line of manufacture, yet we do believe that in many other industries the proportionate difficulties would be very much greater, and, in fact, that these difficulties in many lines would be so great that the introduction of a metric system would result in the complication of a dual system of measurements being in use for an indefinite number of years in this country, which would inevitably place a heavy burden of expense upon many manufacturers.

We are decidedly of the opinion that no compulsory legislation should be forced upon the country. If left as it is, the metric system will be adopted by such lines of trade and industry to which it lends itself more particularly, and if it is such a desirable thing as its advocates believe, it will gradually work its way into the interests of the country generally; but it is folly to attempt to force it immediately by legislation.

From Frederick W. Taylor, Consulting Engineer, Philadelphia, President of the American Society of Mechanical Engineers

MR. TAYLOR'S views are well expressed in the following extracts from his recent testimony before the Metric Committee at Washington:—

Let every man have the metric system if he wants it, but let no set of men be forced to use it merely because a lot of scientific men, who have not studied its working in our shops, wish to arbitrarily force it upon us.

I will tell you why. It is not on scientific grounds at all. I use it myself. But for every time that I use it once, or any scientific man uses it once, every machinist in the country bumps up against it a hundred times a day and all day long. The inch, half-inch, quarter-inch, five-eighths, thirteen-sixteenths, three-fourths and seven-eighths are the machinist's property, his asset. They belong to the machinist, and for his

use they are vastly more convenient and simpler than the metric millimeter ever could be, even if the inch were wiped out of existence.

I was utterly astounded when I came out of college and started to serve my apprenticeship to see my boss patternmaker and other patternmakers go up to a lathe, put a rough piece of wood into it, and, without any measure other than their eye, turn that piece of wood to any size which they wished, from two inches down, and finish it just as accurately as if they had used gauges. I want to tell you this three-quarters of an inch is something to them. It is an absolute fact to them, and the half-inch is one of the important facts of their lives. They live with it. It is a language to them. They talk and think more in inches than in words while at work, and they are doing that all their lives long.

When I was told that they could learn to adapt themselves to any standard, I believed at first that this was the truth; but the more I studied the matter, the more I became convinced that the metric system never could by any possibility be made anything like as convenient or desirable for our workmen as the inch. And what I wish particularly to emphasize is, that the workmen use our system of linear measures far more than scientists and college professors do; that the use they are forced to make of it is radically different from that of the scientist; and that there are ten thousand workmen in the country who would be injured by the compulsory introduction of the metric system to each college professor or scientist who would be benefited by it. In trying to state the workmen's side there are certain facts to which I wish to call your attention:—

1.—It is an absolute fact (not a theory) that in the workshops of Europe the millimeter is the standard of measure universally used, not the decimeter, centimeter, or the meter. In the shops of this country the inch is the standard of measure, not the foot or the yard.

2.—The inch is a vastly more convenient unit of measure for the workman, because its size is much closer to the average of things which the workman has to make than the millimeter, the inch being about the size of the implements conveniently grasped by the human hand, while there are 25.4 millimeters in one inch, or it takes 10 millimeters to measure the width of the nail on the little finger of a man's hand. The inconvenience of this small unit will be shown later.

3.—The use which the workman has to make of the linear standard of measure is directly the opposite of the use which the scientist or professor makes and the real essence of the conflict between the interests of the two lies here.

4.—Worst of all, if the Littauer bill becomes a law, the real metric system will practically not be used, but a "fake" metric system will be forced upon the government departments and upon those having dealings with them. Our ships, and practically everything inside of them, and our ordnance will continue to be designed and built in inches, because it is physically impossible for most of our machines to produce anything but inches; but these inches will have their name changed and take on the "fake" name of millimeters. That is, instead of saying 1 inch, government drawings will say 25.4 millimeters, and instead of saying ¾ inch they will say 19.05 millimeters; but our workmen must continue to use the inch all the same. This is a "fake," not a genuine use of the metric system, and a great hardship for our workmen.

5.—If ever this "fake" is forced upon our workmen, I predict that it will make such a storm of opposition as will sweep those who have been instrumental in compelling them to use it out of political existence.

The third statement which I made

above requires a little further explanation. When a man making a scientific investigation is called upon to measure a given object, it is a matter of comparatively little importance to him whether he uses a scale with inches or one with millimeters, because the actual measuring can be done about as readily with one scale as with the other. The scientist, however, writes down on a piece of paper which is at hand each measure as soon as he makes it, and after all of his measures have been taken down, he usually proceeds to make a calculation or computation of some sort, using the dimension of the object in question in his figuring. For much of this class of figuring the metric system has distinct advantages over the inch system, and, this being the case, the scientific man naturally prefers the metric system, and sees, in nine cases out of ten, no reason why the mechanic should not also use it.

The mechanic, on the other hand, instead of having an object given to him which he has to measure, has a drawing given to him, showing a part of a machine which he has to make, and upon this drawing are written many dimensions. It is the business of the mechanic to go to this drawing, which is kept close by his machine, but not right where he is working, because it would become covered with dirt and illegible if it were kept there; consequently the mechanic must walk a step or two, at least, from his work, read from the drawing the one, two, three, or four dimensions which it is necessary for him to have in order to make the part of the machine which he is working on, and these dimensions he must in almost all cases carry in his head, remembering them while he is either setting the various calipers, gauges, etc., or in many cases throughout the whole time that he is engaged in shaping the pieces.

The mechanic, then, must carry a lot of measures in his head, while the scientific man is able at once to put them down on paper. The mechanic cannot, in most cases, put the dimensions on paper, because his hands are greasy with handling his machine, and also because his hands are busy while he is doing the work. From this it follows that, different from the case of the scientific man, it is of the greatest importance for the unit of measure which the mechanic is called upon to remember to be the one which is easiest for him to carry in his mind.

As I have said above, there are very few objects which the mechanic has to make which are as small as a millimeter, whereas the vast majority of the parts which he has to make, say, on a lathe, will run between half an inch and six inches in diameter. Now, it is a very easy thing for a mechanic to read from a drawing and then remember that the piece which he is going to make is, say, 4¼ inches diameter and 7 inches long. It would be a distinctly difficult task, however, for him to remember these same dimensions if they were expressed in metric units instead of inches; for example, 107.95 mm. in diameter and 177.8 mm. long. This illustrates the fundamental fact that the metric unit (the millimeter) is entirely too small for convenient use by the mechanic; and while at first sight this may appear to be a comparatively unimportant objection, it is a matter of enormous consequence to the workman.

Illustrations of the inconvenience to which this minute unit of measure puts the mechanic might be multiplied indefinitely. I will, however, give one more. Time and again it is necessary for the mechanic, when he reads the dimensions from his drawings, to add up a series of dimensions. For instance, he must read off and add up in his mind, without putting them down on paper, say, 5½ inches plus ½ inch plus ⅜ inch. Any mechanic would, with ease, add in his mind the above figures and say at once,—6⅜ inches. The corresponding metric measure-

ments would be 127 mm. plus 12.7, plus 9.525.

Now I will defy any ordinary mechanic to add up these latter figures without putting them down on paper. And it is to be remembered that if the mechanic is forced to take a piece of paper and perform this sum in addition, it counts more for him than the mere inconvenience,—he loses money by not being able to turn out his work so fast. I would again call attention to the fact that this trouble is brought about by the fact that the millimeter is entirely too small to be a convenient unit of measure.

Referring now to the fourth fact stated by me namely, that if the Littauer bill becomes a law the real metric system will practically not be used, but a "fake" metric system will be forced upon our departments and upon those having dealings with them, I will try to make myself clear on this point.

I designed many of the lathes and other machines that are now in use in the Midvale Steel Works, and am thoroughly familiar, through three years' experience, with the machines used by the Bethlehem Steel Company for making government guns, gun forgings, projectiles, etc., and also with the machines used at the Cramp Shipbuilding Works, in Philadelphia, in building large armour-clads, and the inch is absolutely a part of every one of those machines.

All the dimensions used by them are in inches, or fractions of an inch. All of the gearing and lead screws and the longitudinal and crossfeeds of these lathes are made to work to inches to cut screws, etc., of the United States standard. Now, some of these enormous lathes and other tools took as long as four years to design and build, and, all together, they cost millions of dollars. They embody the inch, and they are made to work in inches, and it is out of the question to cut a real metric screw thread in these lathes.

What the government departments will do if the Littauer bill forces them to use the metric system, will be that they will design their guns and ships in inches, just as they have heretofore, and they will then translate these dimensions, which are really inches, and gave them the vastly more complicated metric names.

The real dimensions will remain inches and fractions of an inch just as heretofore, but they will have the new metric names.

What is the workman going to say and to think when these monstrosities are forced upon him fifty times a day? There would be little or no trouble for the designers in the ordnance department of the army and navy, or even in the shipbuilding department, to write on their drawings these new metric names for the old inches; but the workman who has to first read these new names which are given to his old friends and try to carry them in his head, and then translate them into inches, and then proceed to adjust his gears so as to cut a given thread that is called for, will see no improvement in them over the old system.

It may be possible to design a good many of the dimensions of guns, parts of ships, etc., in real metric measures, and the workman would then merely have the inconvenience and difficulty of using the small metric unit (the millimeter) instead of the more convenient unit, the inch.

But it is entirely out of the question and utterly impossible for the government departments to design all the parts of a gun or of a ship in real metric units; therefore, in order to have anything like consistency, to avoid endless confusion, the easiest way out of the difficulty for the departments would be, as I said before, to use the inch in their designs, and then change, not the dimensions, but merely the names, to the metric system.

From L. D. Burlingame, Chief Draughtsman of the Brown & Sharpe Manufacturing Company, Providence, R. I.

THE efforts to introduce the metric system by the use of an entering wedge of legislation have, during the last few years, met with successive failures. Beginning with legislation making it compulsory both for the government and people, the wedge has gradually been sharpened finer and finer in the effort to make a start, until in the measure before the present United States Congress it is thinned down to making the system compulsory for the departments of the government only. This movement has had all the appearance of a propaganda worked up by the few and backed by theorists. It has been overwhelmingly opposed, however, by practical men, as far as there has been an expression from them.

It has been asserted by advocates favouring this measure that the compulsory adoption of the metric system by the government alone would not affect the people at large and would not cause any inconvenience to manufacturers.

We feel that it would not be possible to isolate the government, treating it as if it had a contagious disease; in fact, that would be far from the ambitions and purposes of the little coteric of men who have been persistently endeavouring to inoculate us with this mischievous metric microbe.

Such an effort may be likened to the introduction from abroad of the gypsy moth into Massachusetts for the purpose of aiding and developing silk culture in this country,—a work undertaken with honesty of purpose, but entirely misdirected, and the effects of which have been fraught with dire results, already costing hundreds of thousands of dollars in the efforts to check it, in spite of which it is still a growing menace. The metric grub, once hatched in the departments of the government as an experiment, would be spread throughout the country by the ramifications of the government service, and, fastening itself on our manufactures, in spite of all opposition, would cause untold trouble and expense.

It is time to make it understood, once for all, that we do not want to make any such experiments; that we want to stop the importation of this dangerous foreign metric pest that it may not be established among us by those whose purpose is to introduce it throughout the country, but who now try to make us think that the government's alone fostering it will not allow it to spread so as injuriously to affect the flourishing forests of our manufactories.

The chairman of the United States Congressional Committee on Coinage, Weights and Measures, in advocating this metric legislation, has flooded manufacturers of the country with statements to the effect that the adoption of the metric system by the government alone cannot affect their business in any way. He has belittled and laughed at statements or arguments showing that such adoption would injuriously affect us as manufacturers.

On the other hand, the director of the Bureau of Standards, working hand in hand with this chairman, believes it will affect the country at large. He has made the following statements in his testimony regarding this legislation before that Committee:—

"The drills, reamers, arbours, etc., would have to be changed if a shop desired to use only even sizes, which would be the case eventually."

And, further, says:—

"I think it will introduce the metric system into the country with a minimum of confusion and difficulty."

Indeed, this position, that the purpose of the government adopting the metric system would be to introduce

it and spread it among the people, seems the only consistent one for the advocates of the measure to take. Even before its spread, however, we should see its serious effects.

I quote from a letter to the Committee written by Mr. D. H. Bates, of the Willcox & Gibbs Sewing Machine Company. He says regarding this law:—

"If passed, it will compel 'all departments of the United States Government to use the metric system.' What does this little phrase involve? Every inquiry, advertisement, order, and contract of the government in which weights and measures are mentioned must thereafter be stated in metric terms, from a trifling order for stationery to a contract for a battleship, in the latter case with its almost infinity of calculation. If a machine or mechanical device of any kind is needed, the specifications must be phrased to fit the metric system, and if the head of a department is unable to express himself in the new language of measures, so much the worse for him. The greatest burden, however, would fall upon the manufacturer; for instance, take 'Schedule 182, Bureau of Equipment, Navy Department,' or 'Proposals for Underwear for Navy Department,' and let us imagine the innumerable data specified in each of those complicated documents expressed in metric terms (if it were possible in the state of the arts to do this with necessary accuracy), and then watch the manufacturer who examines the varied requirements, all stated in a new and foreign language of technical terms, weights and measures, and consider whether he can make an intelligent bid for supplying the government with the articles specified in those documents.

"His goods are designed and finished by another system of measures, and if he desires to make a bid for these articles he must go through almost endless calculations before he can determine practically whether he can make up the goods, and then another series of complicated calculations to enable him to determine the cost of manufacture, and as accuracy is a prime essential in filling government contracts, he may well hesitate before placing himself in the power of an unbending inspector, and if he does finally conclude to bid, he must add a fair percentage to cover new and uncertain risks."

When we add to this complication in dealing with the government the change to the metric system in the postal service, land measures, court proceedings, etc., etc., we see that the introduction of this system in the departments of the government would start forces that, as in the case of the noxious insects, cannot be afterwards checked, even at great expense.

We feel, as manufacturers, that the government should put itself in a position to be the helpers of the people and not place obstacles in the path of progress; that the employees of the government should not take upon themselves to decide this matter for us; that they should not make themselves advocates, using the funds and machinery of the government to advance this metric propaganda.

When I was at St. Louis, at the Exposition, two years ago, I visited the Government Building and stopped to look at the exhibit made by the Bureau of Weights and Measures. The standard metre was exhibited with a notice beside it that it was the standard from which our English measures were derived, and the attendant volunteered the information that our standard for the yard was poorly made and accurate results could not be obtained from it, but that it did not matter, as the metric system would soon be adopted in this country. The supposed great advantages of that system were then explained to me.

This had the appearance of systematic missionary work for the metric system being carried on throughout the Exposition by a department of the government.

With all the effort that has been

made for half a century to force this system on our people, it is remarkable that it has obtained so slight a hold, and this would, in itself, indicate inherent weaknesses in the system.

A MODERN FACTORY RESTAURANT

By F. M. Feiker

IN the great industrial establishments of the present day are to be found many organizations for the general welfare of the employees, corresponding to those services ordinarily recognized as public utilities. There are private telephone systems, fire and police departments, hospitals, and restaurants. While the municipal restaurant is still one of socialism's unfulfilled dreams, in the modern industrial plant it has become generally adopted, and the following description of the restaurant of the General Electric Company, at Schenectady, New York, affords an interesting example of the development of this idea.

During the noon intermission at this factory, only half an hour is taken for dinner, the shop hours being from 7 A. M. to 12 M. and from 12:30 to 5:30 P. M., with a half holiday on Saturday. As a consequence of this short noon intermission many employees were accustomed to bring a cold lunch. The new building was erected especially to provide a means of obtaining a hot mid-day meal. To this end it is centrally located on the factory street near the largest of the several factory buildings, and special provision is made to provide accommodations for a large number of men in a short time. The restaurant is kept open every day and night that the works are in operation.

As the illustration at the head of this article shows, the restaurant building is a two-story structure of simple Colonial design, 150 feet in length and 80 feet in width. The entire building is constructed of moulded concrete blocks, and the dignity of the design so worked out is suggestive of a modern library rather than a restaurant.

THE DINING ROOM FOR FOREMEN AND ASSISTANT FOREMEN

The columns in front, forming one of the structural features in the design, are monoliths of concrete, having been formed in place in sectional moulds. The walls of the building are laid with moulded concrete blocks, and the same material is employed in ledges, façades, and cornices. All the concrete work was done on the ground near the building. No special skilled labour was necessary, ordinary labourers having been employed, with proper superintendence. To avoid the very regular appearance sometimes noted in this method of construction, different faces were used in moulding the concrete blocks, so that the rough concrete surfaces do not present a monotonous effect.

Within the building the finish is hard pine, left in the natural state, and varnished. This finish, together with the general light-tinted plaster walls and many large windows, makes the interior light and attractive. Artificial illumination is provided by both arc and incandescent lamps. The main floors are lighted by General Electric enclosed arc lamps with concentric diffusers, giving a very even distribution of light. Incandescent lamps are used in the kitchen and halls, and for basement lighting.

In general, the arrangement of the interior is planned to facilitate the work of serving many meals in a short time. The main doors open into a corridor from which lead stairways to the upper floor, and swinging doors to the first floor. The doors are arranged in pairs, mounted to swing in and out, respectively, thus avoiding confusion.

On this floor, as shown on this page, there are three double lines of counters, arranged to serve a regular dinner at short notice, and two long short-order counters for those wishing to procure a simple lunch

THREE DOUBLE LINES OF COUNTERS ARE ARRANGED TO SERVE DINNER AT SHORT NOTICE

quickly. Between the counters, coffee urns, steam-heated service-tables, and hot-top tables provide means of furnishing meals during the busy hours without making trips to the kitchen, and save much time generally lost in this way.

In the rear of the first-floor dining room is the principal kitchen. This department forms an addition to the main building, one story in height, and is provided with ventilating roof to carry all odours away from the restaurant. The kitchen is complete in all details, and comprises butchery, scullery, bakery, and the various storerooms, plant for mechanical refrigeration, etc. The equipment is modern in every respect, and includes many labour-saving devices. The various vegetable boilers and soup kettles are heated by steam, which, as well as the steam used for heating the warming tables, hot water tanks, and the general heating system, comes underground from the main turbine power house of the works, some distance from the restaurant building. Among other devices, an electric dish-washing machine is provided, which takes the place of many helpers. Beneath the kitchen is a basement containing a complete ammonia refrigerating plant, a large bakery, cold storage rooms, and toilet and office rooms. The cooling system is piped to all the refrigerating compartments in the building, so that no ice need be carried and much time and labour are saved.

From the basement to the second floor there is a dumb-waiter, electrically operated and controlled from each floor. On the second floor there are three double lines of counters, fitted for quick service in the same way as those on the lower floor. In addition to the counters, two special dining rooms are partitioned off from the main hall, one for women, the other for foremen

and assistant foremen. These are interconnected by folding doors, so that the two rooms may be used as one large private dining room. Back of these private rooms is a small serving room. Meals for 108 may be served at one time in these two rooms.

The total seating capacity of both floors in the restaurant is approximately 1000, and from 1500 to 1800 employees are fed daily.

The manner of operating this restaurant is interesting. With the exception of the dishes and silverware and such small fittings, the equipment is supplied by the General Electric Company, which also heats and lights the building. The operating end is in charge of a restaurateur, who is under contract with the company to furnish meals at a fixed price. As rent, light, and heat are free, an excellent meal can be provided at a low price. A regular dinner, comprising a soup, meat with two vegetables, tea, milk or coffee, and a dessert, can be obtained for 20 cents. A further reduction in the cost of meals is possible by purchasing meal tickets. Six checks can be obtained for $1.10, making the cost per meal a trifle less than 19 cents.

NEW RAILWAYS IN THE PHILIPPINE ISLANDS

By Percival E. Fansler

THE policy of the United States Government, particularly bearing upon its Far Eastern possessions, is a matter of world-wide interest. Since the Spanish War America has naturally been interested in the development of the territory secured from Spain, and other countries have been anxiously waiting to see if "Uncle Sam" would make good his statements regarding his intentions.

Under the able direction of General Wood, Havana, so long a breeding place for yellow fever and other tropical diseases, was speedily transformed into a popular winter resort, and to-day the influx of business and pleasure seekers into Cuba portends a great future for the island.

Of necessity, the development of the Philippines must be along more gradual lines, but it is safe to predict that in a decade or two the territory that has for three centuries moulded under Spanish rule, will compare favourably, acre for acre, with the most productive portions of the United States.

Already the effects of the American invasion have been felt. Manila, the chief city of the islands, is rapidly increasing her import and export trade. The Government is carrying out extensive harbour improvements at Manila and also at Cebu, the principal seaport on the island of Cebu, and at Iloilo, the chief town of Panay.

By far the most important move thus far made by the American Government has been the awarding of concessions for the construction of certain railway lines on the principal islands of the Archipelago. The Government proposed, in an advertisement, to grant perpetual franchises to such persons or corporations as might construct the advertised lines and operate them on the most advantageous terms to the Philippine Government.

As an additional inducement to capital, a guarantee by the Philippine Government was authorized, not to exceed 4 per cent. interest on 95 per cent. of the bonds of these lines up to $30,000,000. The bidders were:—J. G. White & Co., associated with Kean, Van Cortlandt & Co., Cornelius Vanderbilt, C. M. Swift, R. T. Wilson & Co., and the International Banking Corporation, of New York; Speyer & Co., of New York, and Morris McMieken, G. Greiffkins, G. Poncin, Jacob Furth, and E. C. Huges, of Seattle.

Upon opening the bids it was found that in no case had all of the requirements of the Government been met, and all bids were rejected. Upon opening bids for the second time, the proposition submitted by J. G. White & Co. and associates for all of the lines in the Viscayan Archipelago was accepted. At the time of writing awards have not yet been made for the concession on the Island of Luzon.

At the outset it is well to draw attention to the fact that the plans for the construction of these railway

COMMON TYPE OF SOLID WOODEN-WHEELED BULL CART

lines are the culmination of years of study on the part of Government experts. The Philippine Forestry Bureau has prepared accurate maps showing the extent and character of the forests on the islands, the monetary situation was investigated, and the adoption of a gold basis has worked wonders in creating a feeling of stability and security.

The islands, as a whole, are extremely fertile, but it was evident from the first that they could not be materially developed without adequate means of transportation. The United States Census Report in 1905, says:—

"The development of the abundant coal deposits in the Philippines with the harbour improvements above referred to (the harbour improvements at Manila) will make Manila the chief coaling port in the East, surpassing Nagasaki in this respect, for the coal is of a quality equal to that of Japan, and the coaling facilities of Manila will be much superior to those of the Japanese city."

The forests of the Archipelago are of wide extent and embrace a wide variety of woods, many of them highly valuable. Nearly eight hundred species of wood were brought to market during 1902. It is estimated that the amount of timber in the Archipelago is in the neighbourhood of 1,000,000 million feet, or more than double the amount in the States or Oregon and Washington together.

Large areas throughout the islands are given over to the cultivation of rice, cocoa, tobacco, hemp, and sugar, and vast tracts need but the crudest cultivation to yield large crops, but of what use are these natural resources if the commodities can be brought to market only at great expense or not at all? The roads in the islands are notoriously poor, making it practically impossible to transport produce in vehicles of any size; consequently most of the market stuff is taken to the towns on the shoulders of the natives, who carry from 50 to 75 pounds in a pack, and cover 15 to 20 miles in a day. Even at the ridiculously small wages prevalent, however, the transportation costs thus amount to about $30 or $40 per ton. Excepting in the vicinity of the largest towns, only sufficient produce is marketed by the natives to supply

their most immediate necessities; the people, as a whole, are shiftless and indolent.

As illustrative of the great need of means for transportation, it was recently a matter of editorial note in a New York daily paper that an American barkentine had arrived at Manila with a shipload of lumber for the Manila wharfs, only fifty-five days out of Seattle. This ship carried piling and heavy timbers to the value of $9,000, the freight upon which was $14,000. As the average time for a sailing vessel from Seattle to Manila is about ninety days, it will be seen that this was a remarkable trip.

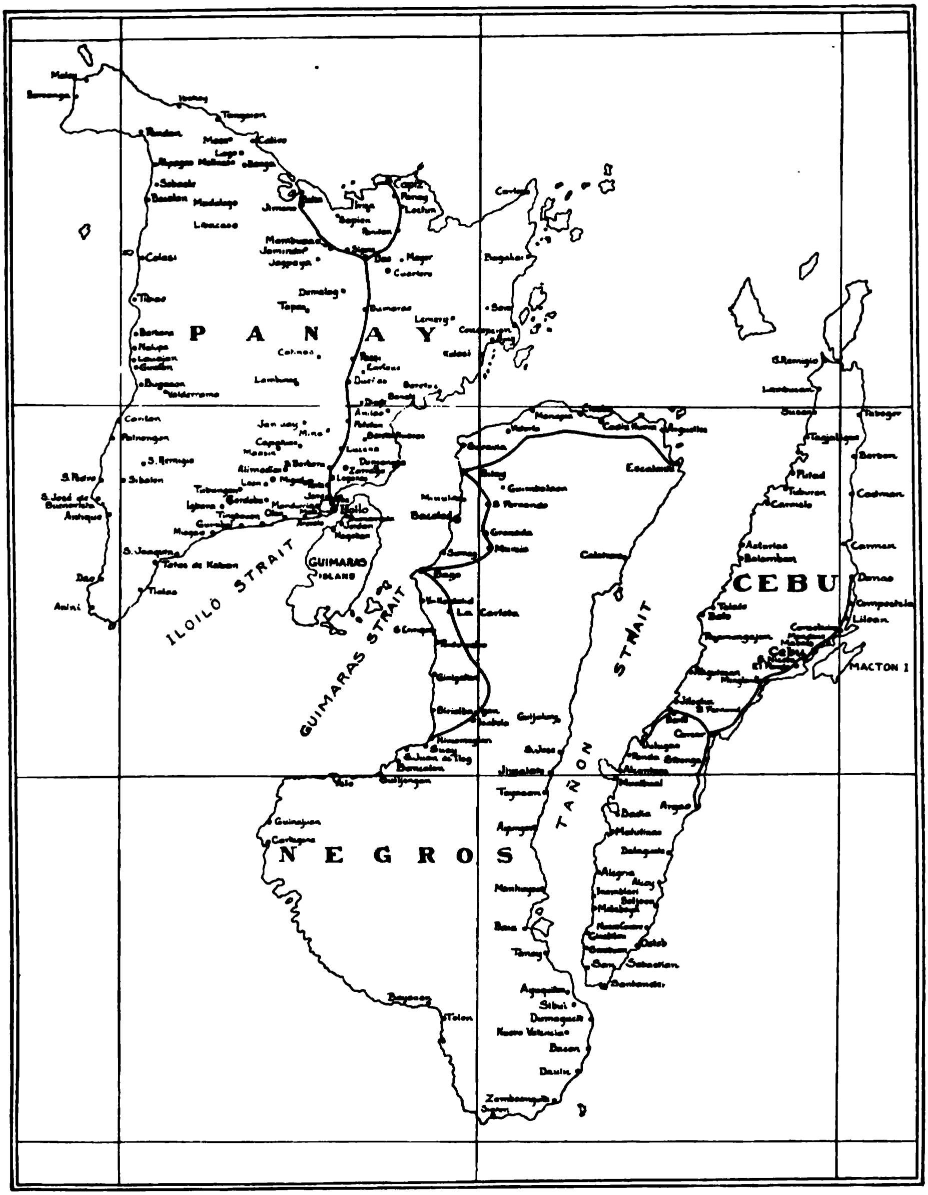
However, the necessity for sending a shipload of lumber from the United States to the Philippines for use in public works at such an excessive freight tariff would not exist if the vast Philippine forests were within easy reach of the market, for these forests abound in timber far better adapted to the work required than the pines of Washington or Oregon; yet, on account of the absence of railways, the character of the streams and the fact that many of the native woods will not float, it is necessary to bring building materials from the United States or Australia to carry on improvements in the islands.

It is natural to expect that the building of any railway will greatly increase the value of the territory served, as well as increase the traffic, both freight and passenger. It is obviously essential, however, that a given territory be developed to a certain stage before financial interests will undertake to build a railway through it. Risks are undoubtedly taken along this line, but it is seldom that conservative financiers will undertake construction of this kind without positive assurances of a fair return.

So it was in the Philippines at the close of the war. The state of unrest which has prevailed, the very character of the peoples inhabiting the islands made it a risk for private interests to carry out large undertakings of this character. A number of American financial and business interests led the way in this respect, and converted the inadequate mule tramways of Manila into a modern electric railway system with branches to nearby towns; but this was a matter of only $4,000,000 or $5,000,000, and as the property was located in Manila, the risk was not comparable with that which would be assumed in building railways through the heart of the islands. The fact that this system, which has been in operation less than a year, is already earning a substantial dividend on its entire capitalization, after paying all of its fixed charges, is indicative of the possibilities in this direction.

One of the most important forces which will have to be reckoned with

A PRESENT MODE OF PHILIPPINE TRAVEL



MAP OF THE PHILIPPINE ISLANDS PANAY, NEGROS AND CEBU, SHOWING PROPOSED RAILWAYS

in the construction of the new railways is the utilization of native labour. It is the same question that is now so prominently before the Panama Canal Board and is probably one that is not understood by the average reader. Just as the question of the employment of Chinese labour on the Panama work is causing agitation, so will the same question be brought up in connection with Philippine railway work. It is all very well to sit back and cry out against the introduction of Chinese labour, but how many of the most rabid have any comprehension of the conditions as they actually are at Panama or in the Philippines?

L. E. Bennett, who made the preliminary reconnaissance for J. G. White & Co., and also went over the proposed route in Luzon for the Government, has had an interesting experience in the Far East, where he has lived for the past fifteen years. The result of his study of the Filipino as a labourer has convinced Mr. Bennett that, under proper conditions, and with intelligent supervision, the average native of the islands may be developed into a good worker. J. G. White & Co., and the Atlantic, Gulf & Pacific Co., pioneers in construction work in the Philippines, have learned that the native must be treated as a child,—he must be cajoled and pampered, and must be furnished with his favourite sport,—the cock fight,—and allowed to attend the numerous fiestas. Mr. Bennett speaking of his trip through the islands, says:—

"The natives have no prejudices, like the Chinese, against railway introduction and modern transportation facilities, and rarely ever disturb railway property or obstruct the track and telegraph lines. In fact, they have shown great interest in the proposed roads and welcome the proposed lines. Even extremely poor people gave me every assistance and accommodation within their limited means while inspecting the routes of the proposed lines in the interior country and evinced unusual interest and enthusiasm over the prospect of railway construction through their locality.

"They had some extraordinary ideas about what a railway is like. Most of them had never seen one. One man in particular wanted to know if he could travel by rail as fast as a telegram, and others were astonished when it was explained that by rail they would be able to travel as far in an hour as they could travel on foot at present in a day. They were much interested in knowing how much it would cost to ride on the railway, and nearly all the young men expressed their desire to work for the road as soon as it started. Steel bridges several hundred feet long, to carry a train, were quite incomprehensible to them. They expected the trains would be ferried across all the large rivers in boats."

The plans of the Government contemplate systems of railways on four of the principal islands of the Philippine group,—Luzon, Negros, Cebu, and Panay. The location survey has not yet been made, although the preliminary reconnaissance has determined the territory to be served.

Reference to the map on the opposite page will show that the proposed lines serve the richest part of the islands and terminate at the most important seaports. From these trunk lines, spurs will be extended into the rich timber and agricultural districts as may be necessary.

On the island of Panay the line runs along the fertile eastern coast, from Ilolio north to Pototan, Passi, Dumarao and Dao to Capiz,—a distance of 80 miles. A branch line 22 miles long will extend from Dao to Batan, an important port in Northern Panay. The road from Iloilo to Passi will traverse a country ranging from nearly level valleys to low rolling lands. The population along this section averages 350 inhabitants per square mile. From Pototan to Passi the population will average over 200

A MARKET SCENE IN SIASSI

per square mile, the road, in fact resembling the continuous street of a country village.

Nearly all of the parcels of occupied ground are less than three acres in size. The "bunching together" of the population in villages is accounted for by the frequent raids of brigands both previous to and during Spanish reign. These bands of Ladrones that have infested the most productive portions of the islands have made farm life, in the American sense, impracticable, and have forced the people to live in more or less settled communities for purposes of protection. This has been one of the greatest obstacles in the way of agricultural development, and is to a large degree the cause of the numerous small land holdings. Another reason is the great productiveness of the soil and the variety of crops that can be raised on a small piece of land. The average size of a farm in the Philippines is only 8.57 acres. In the United States the average size of a farm is about 147 acres, representing a ratio of about 17 to 1. These figures are indicative of the intensive life in certain parts of the islands.

Passi is a large and thriving city, located in the heart of a very fertile agricultural district. Rice and sugar cane are grown in the low lands, and hemp, coffee, cocoa, and tobacco are raised on the high ground. Under the present conditions only a small part of this fertile ground is cultivated, as it costs from $30 to $40 a ton to carry the produce to the market at Iloilo. It will be seen that the opening of a railroad through this territory will treble or quadruple exports from Iloilo at a single bound.

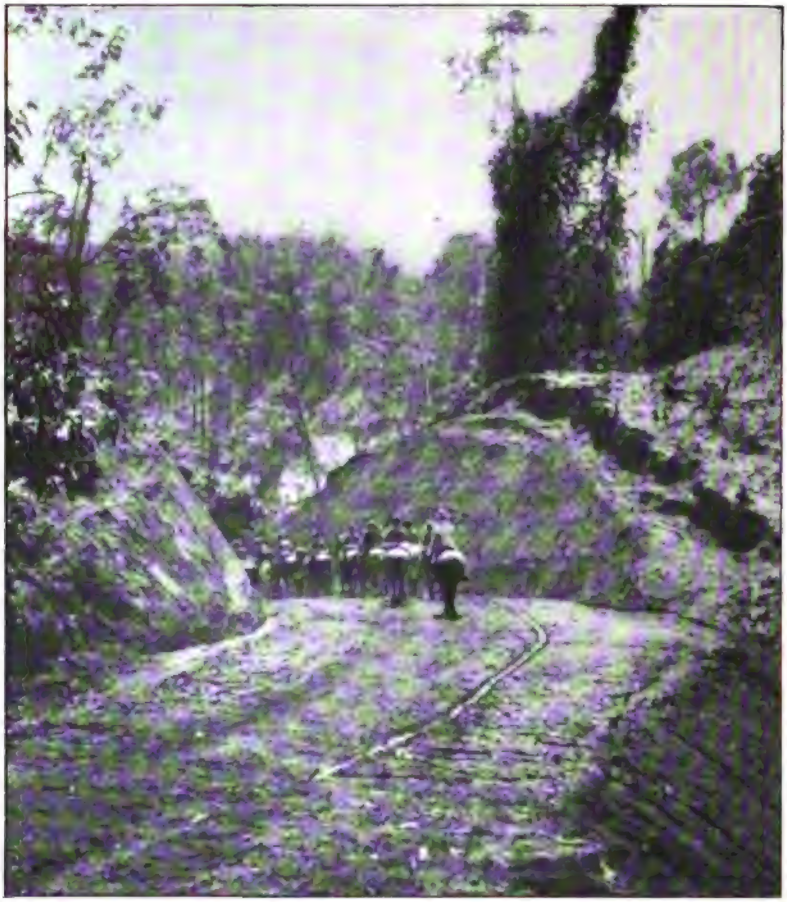
From Pototan north the country is more rugged, but nowhere will heavy grades or extreme curves be required.

Between Passi and Dumarao, a range of hills about 300 feet high and 11 miles across, forms a low divide which is not so thickly inhabited as the first portion of the route, although it offers possibilities for extensive farming. The northern side slopes down gradually into a fertile valley which stretches away to the coast and to the port of Capiz. Dao, the principal town between Passi and Capiz, stands at the junction of two rivers. The ruins of substantial wood and stone buildings indicate that before the war Dao must have been a thriving village. Panay ranks second among the islands in percentage of agricultural land, 24.7 per cent. being suited to the cultivation of the staple products. It is also second in point of density of population, with 161 inhabitants to the square mile. From Iloilo and Capiz large quantities of rice are shipped annually.

Negros, the second island in size, lies to the south and east of Panay. The proposed railway skirts the western and northern coast, starting at Himamaylan, touching at Bago, Silay, Cadiz, and terminating at Escalante. The whole country between Himamaylan and San Juan de Ilog is practically one continuous sugar plantation, the soil being a rich alluvial loam. The plantations have many substantial buildings on them, and in many ways this is the most prosperous district in the islands. The land holdings on Negros are nearly all large tracts,—from 200 to 2000 acres. The following is taken from Mr. Bennett's note book, kept on the previously mentioned reconnaissance:—

"Leaving Isabela early in the afternoon we arrived that night at the foot of a large volcano, where we spent the night with an unusually intelligent native lieutenant of the constabulary in command of a detail stationed there to catch some cattle thieves who had been operating in the neighbourhood. He had been to the St. Louis Exposition and had just returned from the United States.

"The next morning he accompanied our party to several sugar plantations, and from a small hill near one of them a planter showed



ONE OF THE NEW MILITARY ROADS BUILT BY THE GOVERNMENT

me the whole surrounding valley, which was a magnificent sight. We could see about 20,000 acres of rich sugar land still uncultivated for want of good roads and transportation facilities. The gently sloping sides of the nearby volcano showed another 20,000 acres suitable for growing coffee, cocoa, rubber, gutta percha and manila hemp. One enterprising native planter had started a plantation on the volcano slope and had demonstrated that it was possible to cultivate all of these products successfully, but he was unable to make the venture pay for want of communication with the markets.

"Leaving this valley we crossed a low range of foothills about 5 miles across, which were uncultivated and sparsely inhabited. On the other side was another valley of sugar plantations. For seven hours we passed through a continuous line of plantations, arriving at La Carlota about 10 o'clock in a drenching rain. We tried to get a night's lodging at the house of the mayor, but he and his chief of police had gone out to spend the night with some planters and to have a game of "monte." A frightened policeman whom we encountered finally took us to the house of an American school-teacher who put us up for the night.

"The next day being Sunday, we rested, and in the evening our pedagogue host took us to the Planters'

Club, where we met some of the leading native planters. The club house was well furnished, and they kept on tap several of the best known brands of American and Scotch whiskey. The members played poker, and several of them could swear fluently in English, demonstrating in various ways that the village of La Carlota is fast attaining a high state of civilization.

"Early Monday morning we started on our way to Murcia, where we arrived at night, having passed through extensive and fertile sugar plantations, corn fields, and much wild land, uncultivated for want of roads. From Murcia we went down to the sea to the port of Silay. Here we spent the night very comfortably at the residence of Senor Domingo Hernaiz, a rich native planter. On the following day our host accompanied us about 20 miles on our journey along the coast to Manapla. This is a town which does a considerable business in native timber, the logs being floated downstream with bamboo floats from the forests several miles back in the interior. These forests extend inland to the summit of the volcano. There are thousands of acres of rich timber land awaiting the coming of the railway to be opened up. It will pay well to build logging lines from the main line into the forest.

"From Manapla we continued on to Cadiz the next day where we were entertained by the mayor and the American school-teacher. An impromptu dance was arranged for us, which was not altogether enjoyed after a long day's ride on horseback. The teacher told me of having established a young ladies' school for teaching improved methods of cultivating the soil, but at first his pupils, who belonged to the leading families, brought servants along with them to the gardens to do the work. When they finally were made to understand that they, and not the servants, were to be taught, they willingly undertook to do the work and were then making good progress.

PRESENT METHOD OF LOADING VESSELS IN THE HARBOUR OF CEBU

"Leaving Cadiz in the morning we arrived at night at Escalante, the port of Danao, at the mouth of the Danao River. This river is 700 feet wide and 50 feet deep and affords good anchorage for eight or ten steamships. There is a bar at the

A WAYSIDE INN

LOCATING THE SITE FOR A BRIDGE OVER MAGAT RIVER

ESCORT OF NATIVE SOLDIER WHO ACCOMPANIED MR. BENNETT ON RECONNAISSANCE

mouth of the river which must be first dredged."

The island of Negros is capable of producing 400,000 tons of sugar a year when cultivated and developed with modern appliances and provided with transportation facilities. The country is well drained and slopes gradually toward the sea on all sides from the volcano in the center of the island. The soil is volcanic ash and mud thrown out by the eruption of past ages; there is no better soil anywhere for the cultivation of sugar cane. On this island 59 per cent of the male population are engaged in agricultural pursuits.

The cultivation of the cocoa plant, from the seed of which chocolate is obtained, is carried on to a limited extent in the northern portions of Panay and Negros, and has proved a highly profitable and promising branch of agriculture. It is stated that a cocoa plantation in full swing will yield $500 or $600 per acre.

Cebu is a long narrow island, separated from Negros by the strait of Tarrow. From its principal seaport, Cebu, on the eastern coast, the proposed lines runs north to Danao, on Danao Bay, and south through Naga, Minglanilla, Carcar, and Sibonga to Argao, with a spur from Carcar across the island to Julugao, a port in the west coast.

Cebu has a larger proportion of agricultural lands than any other island in the archipelago, about 26.3 per cent., while 68 per cent. of the population are engaged in farming. It also has the greatest density of population, 336 per square mile. This enormous population is concentrated along the coast to be traversed by the railway, and is composed of one of the most highly educated of the tribes.

There is only one steam railway now in operation in the Philippines, running from Manila to Dagupan, on the island of Luzon. Reports from this road show that about 66 per cent. of the total revenue are de-

rived from passengers, and 34 per cent. from freight. The freight, however, is increasing.

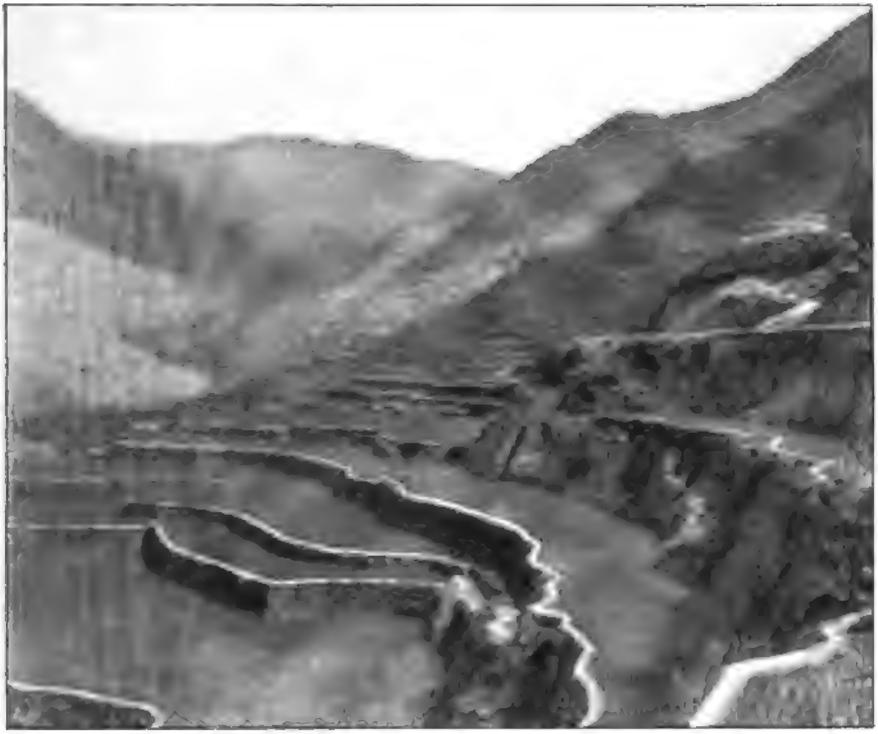
Railways are operated very economically in the Orient, largely on account of the low cost of labour, operating expenses on the existing line averaging only about 45 per cent. of the gross receipts. The natives make reliable and cheap section hands, good foremen and engine drivers for locomotives, and will undoubtedly develop into entirely satisfactory telegraph operators and station agents.

The machinists and engineers are the highest paid of the natives, receiving from $35 to $50 per month. Section hands earn about 30 cents per day, foremen and station agents $15 to $25 per month, brick masons 50 cents per day, carpenters 75 cents, day labourers 40 cents, and stone masons 50 cents. The average wage of the hired Filipino for the entire islands is only about 30 cents per day. The natives, as a whole, are slow to learn, and in some respects are unreliable, but they may generally be considered more satisfactory than any other nationality for the work they have to do.

The fares for passengers are generally much lower than in the United States, and traffic is divided into three classes. Fully 95 per cent of the traffic are third class, and while it now seems necessary to have first class, as a small percentage of foreigners and educated natives object to riding with the poorer class of natives, the second class should be done away with altogether.

Freight rates in the Philippines are higher than those prevailing in the United States, ranging from $5 to $10 per ton for a 100-mile haul, and another interesting fact is that large freight cars do not pay, as an average carload is only about 4 tons, this accounting for the necessity of a high freight rate. The natives ship in such small quantities that it is almost impossible to get a full load even for a 10-ton car. Few merchants ever ship a full carload of

THE PRESENT METHOD OF TRANSPORTING FARM PRODUCE



TERRACED RICE FIELDS IN BONTOC

merchandise. The Chinese merchants are the largest shippers, and by far the best business men in the islands, outside of a very few prominent foreign houses which do almost exclusively an import and export business.

The lines which are at present under consideration are narrow-gauge railways, with a 3-foot 6-inch track, and seem fairly well suited to the requirements of the island traffic. They follow the low lands wherever possible and have fairly easy grades and curvature. It is believed that in no case will the grades exceed 1½ per cent., and that only for inconsiderable portions of the line.

Probably the greatest difficulty which will have to be met is the extremely heavy rainfall during certain portions of the year. As much as 10 inches of rain has been known to fall within a day, and the average rainfall for the year is approximately 100 inches. This necessitates an abnormal provision for flood openings of all kinds, it being estimated that certain lines will require fully 3 per cent. of the total mileage to be allowed for these flood openings in the way of culverts, bridges, and trestles. The construction itself will not be difficult, as there is scarcely any portion of the line in which steam shovels cannot be worked.

Mr. Bennett, who will leave again shortly for the Philippines in connection with the construction, says in regard to the preliminary survey which will be started at once:—"Travelling in the islands is difficult, in many places almost impossible when undertaken away from the beaten paths. In surveying for the new railway location it will be necessary to leave the regular highways, and this will be slow and expensive work, on account of

the dense growth of vegetation. Grass grows to a height of 10 feet and it is impossible to ride through it on horseback. Vines and plants spring up everywhere, many covered with briars and thistles, and about the only way to get through such portions of the interior is to send natives ahead with bolos to cut a path.

In this work it becomes necessary to work entirely by compass. Working from daylight to dark it is possible to explore from 6 to 9 miles of the country per day. The soil is so rich and other conditions are so favourable that a path cut in this manner will be completely closed to traffic within a few months.

Tents and much of the usual outfit used in surveying in the United States are too heavy for transportation, and are usually dispensed with, as it is an easy matter to provide a temporary substitute for a tent. Bamboos, palms of many varieties, and long grass of many kinds abound in every part of the Archipelago.

Just before nightfall, a site for the camp having been selected by the chief of the party, the natives fall too and erect a very creditable hut of bamboo covered with a thatched roof. The entire structure is built without nails, and in some cases the side walls are omitted. A shelter of this kind can be completed in an hour by half a dozen natives who are expert at this kind of work. Transportation of supplies is a difficult and expensive task in making a survey in the Philippines. In some cases it is possible to send ahead stores by boat. At other times where navigable rivers cannot be utilized, bull carts, pack animals and the natives are pressed into service. Many of the rivers are very shallow, and in such a case bamboo rafts come in very handy as they draw but 5 or 6 inches of water.

Pack animals carry loads of about twenty-five pounds on their backs, and where cart roads exist, bulls and carabaos will pull from 500 to 600 pounds in a cart. Where there are neither roads, trails nor rivers, it is necessary to divide the loads up into small packs of from forty to sixty pounds for transportation on the backs of natives. Thus it will be seen that quite an army will be required to carry out the survey which must be made before active construction work is started.

The fact that land is held in such small parcels will make it unusually difficult to acquire a right of way, on account of being obliged to deal with so many different owners of property. Titles are often very difficult to ascertain, most of the natives having no titles other than possessory rights. When they are able to prove to the courts that they have lived on the property for several successive years in undisputed possession and have cultivated the soil, that is considered by the courts as proof of ownership, unless some other person can show documentary proof.

Taken all in all, the construction of these railways in the Philippines will add a great deal to our knowledge of the Filipino character and his ability as a labourer. It will probably require from three to four years to complete the system, and by that time the majority of the natives in the sections traversed will undoubtedly become acquainted with Western methods and ideas.

Those who have lived in the islands and made a careful and unbiased study of the conditions as they exist, and the possibility of future development, are almost unanimous in their statements that there is a great deal of good in the Filipino, and that under proper handling, he will in a few years be far removed from the typical native of Spanish times.

The writer desires to express his indebtedness to Mr. William Dinwiddie, former Provincial Governor of the Province of Lepanto-Bontoc, and Mr. L. E. Bennett, for the photographs used in this article.

GETTING NEW BUSINESS FOR ELECTRIC CENTRAL STATIONS

By C. S. Vesey Brown

In addition to what has already been printed in the April and May numbers of this magazine on the subject of "Business-Getting for Electric Central Stations," Mr. Vesey Brown's article will prove especially interesting as detailing, to some extent, how the business campaign is conducted in Great Britain, where municipally-operated electricity works are factors in the case. Still other articles on the subject of "Business-Getting" will follow in succeeding issues.—The Editor.

THE business of obtaining consumers of electricity is not what it was. Twenty years ago, electricity supply was considered only from the lighting point of view. It was the rich man's light, and owing to the facility with which it lent itself to decorative purposes, it was easily introduced to houses of the well-to-do. Gas was not what it is, for the era of the incandescent mantle had not arrived. Times have changed, however, and each day develops the keen competition of cheap production and cheap light.

That the question of canvassing is becoming a burning one is evidenced by the fact that a prominent position is given to its proper organization in all well-managed concerns. For example, the North-Eastern Railway Company recently appointed a commercial agent whose business it is to catalogue and tabulate all sorts of vacant sites for different classes of manufactures; to make himself thoroughly acquainted with the facilities on every part of the North-Eastern Railway system which will induce manufacturers and traders to settle there. The consequential advantages of this class of business are self-evident and if the department is properly organized there is no doubt as to its ultimate results.

In the same manner, electricity supply undertakings should be run in order to induce business, and it is only now that the question is being tackled in a business-like manner. The details of the organization of such a department should be clearly defined, and they should include the following, amongst other requirements:—

1.—Data as to the different classes of property within the area, subdivided into:—

(a) Residential property (divided according to ratable values).

(b) Shop property.

(c) Licensed houses, clubs, hotels, theatres.

(d) Places of worship, public halls, institutions, schools.

(e) Warehouses, offices, banks.

(f) Manufacturers, classified according to trade.

(g) Sundry special consumers, such as tramways, railways, canals, docks, government property (post-offices, customs, bonded warehouses, etc., etc.), collieries, etc., etc.

2.—Particulars of the tariff for each class, of course, should then be stated.

3.—Particulars as to prices of vari-

ous classes of installations, for wiring fittings, with terms for purchase.

4.—Particulars of special requirements for power users, such details as hire of motors, and cost of motors, if purchased outright.

5.—Examples of the best and worst class of power or light user in the district who is supplied at the tariff applicable to each particular case.

Many other details may be added; but, in the main, the above will be found to furnish a good ground on which to work up an efficient business-getting department.

Having tabulated whatever data may be considered necessary, the next question is the method of carrying out systematically a scheme whereby the electricity undertaking may know how far its organized canvassing department is doing its duty, and this depends largely on the employees who do the work. "Results speak for themselves," and tact and confidence in the business they represent will be the safest and surest means of assuring success. These remarks apply as well to municipalities as to companies.

As an aid to canvassing, the necessity of being able to point to the reliability of the supply is a powerful factor in arguing in favour of electricity. The day has gone by when the question of dependence on the supply being kept up to a standard pressure available at all times and for whatever maximum demand it is designed, is of secondary importance. Competition is too keen, and the consequences of stoppage are so vital that reliability is the first consideration of every electricity undertaking.

In the early eighties, and down to about 1899, the electricity supply business in the United Kingdom was entirely in the hands of limited companies. There were practically no municipal electricity works in operation until after this date; and the subsequent development of electricity supply by local authorities and their methods of canvassing for consumers must be considered separately from the methods adopted by the limited and statutory companies which were estalished before that date.

Dealing with municipal enterprise first, one finds that, as a rule, the method adopted in canvassing for consumers consists mainly in the publication and distribution of suitably illustrated pamphlets on the systems of "free" or "assisted" wiring, the hiring-out motors, and generally, examples of existing installations of light and power.

As far as one can gather, the organization of special canvassing departments has not yet been carried out to a very great extent, though in a few places, like Peterborough, the fact is advertised freely that cheap power and cheap sites are available for manufacturers, and others have tentatively adopted "maintenance of lamps," as at Tynemouth, or "new lamps for old," as at Bradford.

The majority of municipal electricity undertakings are engineered and managed by one man entirely, and a part of his business is to attend to prospective consumers either by letter or personal calls. The information that "So and so" is considering electric light or power is sometimes conveyed to him by one of the numerous canvassers employed by manufacturing companies or wiring contractors; and thus, to a very large extent, actual canvassing by the municipality is left to private enterprise, the engineer or manager only following up definite inquiries as soon as he is put into possession of the information.

As a rule, the method of canvassing for consumers does not arise until the work has been in operation for some time, as it is found that at the commencement of the supply the laying of the cables and the introduction of electricity supply generally induces a certain proportion of the inhabitants to adopt electricity for lighting or power; and it is only when what one might term the most progressive consumers have been

connected that the slackening in the demand necessitates special action and it becomes necessary to adopt artificial methods to induce further business.

It is then that the question arises as to the best methods of advertising the business and dealing with it promptly and effectually. Provided a sufficiently energetic chairman of committee and engineer who are not bound by too stringent regulations of the main body of the council, there are plenty of methods which can be adopted to improve the business, and, amongst these one may mention pamphlets, lectures, exhibitions (either permanent or temporary), the permanent exhibitions being situated somewhere near the centre of the town, and placed so as not to interfere with the local wiring contractors' business.

One of the most important points in the success of any scheme for developing the demand is that of price, and here, to a certain extent, the committee's hands are tied in a manner quite distinct from the company-owned electricity works. As the business within the area of a municipally-owned electricity works increases and comes within the reach of the large power or light user, so it is found that he requires special attention in the matter of price; and if the committee are to deal with this in such a manner as will induce business, they must be prepared to offer such advantage in price as will secure a reasonable return on their outlay, and, at the same time, satisfy the consumer's ideas as to cost.

On the whole, one may say that the canvassing of fresh consumers by municipalities is hedged round with difficulties which do not apply to the same extent where the business is in the hands of private companies. Such municipal authorities as have taken the bull by the horns and introduced "free" wiring and motor hiring and other necessary adjuncts to the electricity supply, have found that it pays to do so; but they have in many cases come across an amount of opposition to the proposals which have seriously endangered their ultimate success.

Generally, one may congratulate them that their business has extended as rapidly as it has done with such limited opportunities of using methods of canvassing which, rightly or wrongly, are not considered to be part and parcel of a municipal electricity business. On the other hand, when one looks at the methods employed by the companies who own electricity supply undertakings, we are struck by the great vitality which is displayed in some quarters, and by the indifference shown in others.

In the early days, electric lighting companies depended very largely on canvassers, who were paid by commission on the number of lighting consumers who were connected with the system; but, as the consumers gradually thinned out, the canvassers were dispensed with until the time arrived when the company had to employ some artificial means, such as "free" and "hire purchase" wiring, prepayment meters, and also to look kindly on power users.

It is not many years since electric power was introduced to any great degree, and, for some time, the user was left to his own devices to determine to what extent and in what manner he should apply electricity in his own establishment. The case is a very different one nowadays in this respect, and the probable lighting consumer, to a certain extent, is allowed to be relegated to the background, while the power consumer is being favoured with all sorts of tempting offers to make use of electric service.

It is now the rule rather than the exception with limited companies that there is an organized canvassing department, to deal with probable electric power and lighting users. The competition of suction gas, town gas, incandescent gas mantles, high-pressure gas, all require to be dealt with by a staff trained to all sorts of argu-

ment and fortified by facts which will enable them to argue and convince the prospective consumer of the merits of electricity supply against any other form of power or light.

Taking a few examples of how this matter is handled, one may gather a great deal that is good and a great deal that is inefficient. Starting with the district in which the writer has been at work for some time, one may mention what is done by the Newcastle Electric Supply Company and the Northern Counties Electricity Supply Company. The Newcastle Electric Supply Company devote a considerable sum of money each year to a publication (nominally a monthly periodical) called the "Tyneside Electric Pioneer," which brings into greater prominence some of the most attractive features in electricity supply which are in operation in the neighbourhood. The company have a department which engineers, both commercially and technically, the schemes requisite for convincing consumers that electricity is the best power for their wants. Where a power or light user wants to know the probable cost of electric power or light, the company supply him with all the definite information obtainable either by calculation and estimate on his own figures or by comparison with a similar business elsewhere.

The Northern Counties Electricity Supply Company, with which the writer was associated for five years, has developed a business of "free wiring and prepayment meters" to a remarkable degree. As the company operates electric power stations in areas which are mainly inhabited by working classes, such as are employed in collieries, shipyards, on railways, etc., the necessity for a special attraction in order to induce custom became part of the company's programme of operations.

Free wiring and slot meters have been, and are being extensively used. The free wiring by itself is not so much in favour as it was, owing to the abuse to which the system lent itself for various reasons which need not be explained here. Free wiring for a limited number of lamps and combined with a penny-in-the-slot meter has, however, been developed to a remarkable degree, nearly 5000 houses having been connected in three years. Beyond facilities for motor hiring, and the above slot meter system, the company do not take any steps to induce further custom except through the ordinary channels of canvassing by wiring contractors.

Several companies on the North-East Coast hire out motors to very large users, such as shipbuilders and engineering works, on the basis of 15 per cent. on the capital outlay involved (5 per cent. for interest, 5 per cent. for depreciation, and 5 per cent. for maintenance), and the companies maintain the motors completely free from any charge to the consumer, willful negligence and careless handling excepted, the agreements for the hire running, as a rule, for five years.

In other cases, the motors are hired out at a certain fixed rate per quarter, up to, say, 10 H. P. As the capital laid out for the larger sizes of 5 or 10 H. P. is considerable, the consumer is required to enter into an agreement to pay the rent for the motor and other apparatus supplied with it for a period of at least three years: for motors smaller than these sizes, the rent is payable only quarterly.

The motor hire rates for these small sizes ruling in the North-East Coast district may be taken as follows:—

H. P.	Volts	Revs.	Hire per Quarter
½	220-230	1.400	10/6
1		1,350	15/–
2	440-460	1,200	19/–
3		1.150	26/–
5		965	30/–
8		970	37/6
10		950	45/–

These prices include all the necessary wiring, starting switch, etc.

Nearly all the statutory power companies, such as those established

in South Wales, Yorkshire, Cleveland and Durham, Lancashire, Derby and Nottingham, and other districts, make use of a pamphlet known as "Electrics." This pamphlet deals almost exclusively with power application, and is plentifully illustrated with examples of how various applications of electric power are carried out.

In the case of the Midland Electric Corporation, the method adopted for dealing with the canvassing department appears to be the soundest that the writer has yet seen. Each district of the company's power distribution area is allotted to a canvasser, who reports daily to the head office as to his visits to various people. In his report, he gives the reasons of the canvassed person for either adopting or not adopting electricity. The returns are tabulated. Those which can be dealt with by the company are promptly taken in hand, others are divided out to the wiring and other contractors in the neighbourhood, who report, in turn, what they have done, and, in this manner, a complete record is kept of every probable consumer in the company's area. The tabulation of the record involves a certain amount of clerical work, but the results justify the methods adopted, and, in addition, the good-will of every wiring contractor, electrical agent, and manufacturer is obtained by the impartial division of the reports of canvassing to enable the consumer to be dealt with promptly on the best terms.

Edmundson's Electricity Corporation, who control a great number of electricity works, have largely adopted the travelling exhibition as a means of improving their business. The effect of the exhibition is felt for a short time; probably it stays a month in each town, and then passes on to another place, returning in due course, with something new added to its collection, and in this manner public interest is kept alive.

Other companies adopt the rough-and-ready method which was once described to the writer by a commercial traveller for leather belting, who said that wherever he saw a chimney he made a practice of calling (as belts would certainly be used there); and, by the same reasoning, wherever one hears a noise of moving machinery, it is advisable to call and see if electricity can be supplied by the local electric power station.

Among the pamphlet forms used in the business of getting customers is a "popular" series, issued by The Electricity Publishing Company, of Manchester, who, in clear and non-technical language, easily understood by the ordinary man-in-the-street, deal with the various uses of electricity for either lighting, cooking, heating, ventilating, etc.

The difficulties of electricity supply undertakings to obtain more consumers are, to a certain extent, the result of the practice of obtaining from the consumer a signed application form, which to all intents and purposes, is made into an agreement, and which, in a large number of cases, frightens the would-be consumer. He has not been used to making such agreements with the gas or water company; in fact, he is seldom asked to do more than pay a small money deposit to cover meter rent. As a rule, he just tells the gas or water company that he has entered into the possession of his premises and requires the meter or the water tap to be connected, and beyond this he is concerned only with the quarterly or half-yearly account, when it is rendered.

Undoubtedly, in time, these application forms and agreements will have to disappear from the business of electricity undertakings, and every consumer will have to be treated in the same manner in which the gas and water companies now treat their consumers.

On summing up the situation and reviewing all the points connected with the business of getting consumers of electricity, it must be recognized that more attention should

be paid to canvassing. Electric lighting committees and companies will have to recognize that the success of their undertaking depends as much on the commercial organization as on the technical design of the plant, and that "importunity," coupled with "tact," will accomplish a great deal that at present appears unsurmountable.

Current Topics

Buying coal on the heat unit basis is becoming increasingly and deservedly common. It is not so long ago that it was considered by many as a laboratory refinement with which the power producer and user could not be expected to have any patience, and even the engineering joke-smith took it up as a fit subject for his funny column. But laboratory work and every-day work in the shop and factory in a multitude of fields of endeavour are being intermingled more and more, and buying and selling coal on analysis is one of the things to which this practice has given a recognized commercial standing. One of the latest illustrations of this is afforded by the city of Chicago, which is said to have let contracts for 200,000 tons of coal on this basis, the form of contract being somewhat on the lines laid down in the February number of this magazine in an article entitled "Coal Testing: Its Importance in Industrial Economy." In the case of the Chicago deliveries, if the coal test shows 13,000 British thermal units, moisture 10 per cent., and ash 8 per cent., the price is to be $2.30 per ton; but if the coal varies in heat units, the price is to vary accordingly. The following is the method of procedure reported:—Take the original British thermal units of the coal, 13,000, and if the moisture is 10 per cent., deduct 1300, which would leave 11,700, or the commercial British thermal unit of the coal as delivered. Multiply that by 2000 pounds to the ton, which would give 23,400,000 British thermal units per ton. As the price is $2.30, divide the number of British thermal units per ton by that to find the British thermal unit for 1 cent per pound. Add the cost of removing the ashes at 50 cents a ton, making the basis of the contract in this case about 100,000 British thermal units for 1 cent. On a 5000-ton contract an analysis of the coal is made once a week. The sample is taken by the regular method and analyzed and reported to the consumer and the contractor. If the British ther-

mal units for 1 cent are lower than 100,000 the price drops accordingly, and the price always bears the same proportion to the original contract price.

It is only a few months ago that the 42,000-ton "Amerika," of the Hamburg-American Line, represented the latest and best that was afloat in the way of ocean passenger steamships. To-day, though not exactly eclipsed, the "Amerika" takes second place to the "Kaiserin Auguste Victoria," of the same company, which recently arrived at New York on her maiden voyage, and in the interval, too, there has been a second newcomer with claims to distinction, the "Nieuw Amsterdam," of the Holland-America Line, whose first trans-Atlantic voyage was made in April. Though not quite so large as either of the other two, the Holland liner is nevertheless of formidable proportions and commanding attractions. Her dimensions are:—Length, 615 feet; beam, 68½ feet; depth, 48 feet. Her registered tonnage is 17,250, and her displacement is 30,200 tons. She is propelled by twin screws, and these are driven by two separate sets of quadruple expansion engines of 10,000 horse-power each. Five decks are set apart for the accommodation of passengers. The main saloons are centrally located, high above the water, and conveniently connected with the other social halls, the staterooms and the promenade decks. These features, in the main, resemble the arrangements of other recent ships, but with the quest for novelties and improvements which marks the progress in ocean-travelers' equipment, it would probably be remarkable not to find something new on the "Nieuw Amsterdam." Hence we are quite prepared for even so distinct a novelty as a Japanese tea room, for example. This is located in the centre of the promenade deck. This room, which connects directly with the promenade deck and the first-class smoking room, is decorated with Japanese art panels especially made for this purpose. The room is paneled in modern Japanese style, in polished satin wood, with black inlaid lacquer work, specially imported from Japan. The ceiling is decorated with paintings on linen. A coloured dome is tinted, and painted glass admits light by day, while suspended Japanese lamps and electric lights supply illumination at night. It seems almost needless to say that, in point of general luxury of equipment, fire protection, wireless telegraphy, and the numberless other details of latter-day Atlantic passenger steamship requirements, the new vessel has been liberally endowed. Exclusive of the crew, she has accommodations for 450 first-class passengers, 250 second-class, and 3000 third-class,—3700 all together. She was built by Messrs. Harland & Wolff, Ltd., of Belfast, Ireland.

An excellent example of emergency engineering was afforded at the beginning of the past winter by a large electric central station which, partly through accident and partly because of rapid growth of its business, found itself seriously short of steam generating capacity, with no prospect of being able soon to supply it through boiler house addition. With the station located by the riverside, taking steam from an adjoining steamboat suggested itself as a solution of the difficulty, and a plan to that effect was accordingly carried out. A large passenger steamship, out of commission at the time, and laid up for the winter, was chartered, brought alongside the power-house dock, and her boilers, disconnected from her own engines, were suitably connected with the supply system of the station. The connections were a series of large inverted U-shaped flexible copper pipes, uniting a steam manifold on the power station

dock with a manifold on the upper deck of the steamer, the manifold on the dock being in communication with the main steam header in the station, and the manifold on the boat communicating with the latter's boilers. The U bends provided satisfactorily for the rise and fall of the steamer with the tides, affording a maximum range of about 7 feet. The whole expedient rendered good service for several months.

One of the teachings of the recent fearful earthquake and fire tragedy at San Francisco is tnat skeleton steel construction is more nearly earthquake-proof than any other known form, and becomes almost perfectly so when coupled with armoured concrete walls. When we consider the bird-cage plan of the modern steel building, the perfect bonding of all its parts, and the inherent elasticity and toughness of the material used, we need seek for few more reasons to support this view. Reduce the heights of the buildings, and another important advantage is gained, as the stresses in the frame, due to lateral movements of the earth, thus become less. Armoured concrete walls are homogeneous and become integral parts of the steel frame, so that the final structure is likely to prove almost ideal in earthquake wrenchings. It is to be hoped that these facts will be duly considered in the rebuilding of San Francisco,—in fact, in all places subject to seismic disturbances.

It is somewhat astonishing that after an experience of nearly twenty years in the use of lead-encased rubber compound and paper cables in underground conduits, there should be any ignorance on the subject of their durability and of other features connected with their operation. Such appears, however, to be the case. For example, it was a cause of astonishment to many of those present at the last meeting of the American Institute of Electrical Engineers to hear Mr. Wallace S. Clark inject into his paper on "Underground Cable Practice" the statement that the lead covering was used on rubber cables as a mechanical protection and not as an insulator. He said that many engineers appeared to be of the latter opinion. If this is a fact, such ignorance is to be deplored, and there does not seem to be any good reason for its existence. Certain it is that in papers and technical periodicals for the past fifteen years the object of the employment of the lead covering has been over and over clearly stated, mainly, it is assumed, in such cases for the information of laymen. For instance, in a paper on "The Practical Working of the Electrical Subways of New York City," read before the American Institute of Electrical Engineers in 1890, it was stated that "all of these cables are lead-covered as a precaution against mechanical injury, action of acids, etc., or moisture. * * * The cables used in the electric light service in the New York Subways are, without exception, lead-covered. In the case of fibrous insulation this is essential to exclude moisture, but not in the case of rubber cables, except as a protection against gas and acids, and, to a certain extent, mechanical injury." On the question of the durability of underground cables, Mr. Clark cited actual instances from the experience of the Cataract & Power Conduit Company, of Buffalo, N. Y., in which lead-encased rubber compound cables have withstood a pressure of 11,000 volts for over eight years and under arduous conditions as to abnormal pressure, without any evidence whatever of impairment, either electrical or electrochemical.

This is confirmatory of the experience obtained with lead-cov-

ered rubber cables in the early days of underground work in New York City. Thus, in an article on the electric cables in the New York subways, appearing in "The Electrical Engineer," of January 11, 1893, a writer stated:—"There is, as yet, no indication of deterioration of the lead-covered cables, the fibrous insulation retaining its original appearance, and the elasticity of the rubber being as pronounced as when the cables were first laid, in many instances from three to four years ago. It now seems safe to say that, barring mechanical or (abnormal) electrical injury, the life of these cables will be equal to that of their lead covering. * * * There having been but one instance of deterioration of the lead covering, the life of the cables may be considered as practically unlimited." With regard to these particular cables, it should be said that, as a rule, the thickness of insulation used was considerably less than is now deemed good practice. The whole question of the practicability of underground operation was at that time (1890-1893) undergoing test. The high-tension electric lighting companies were, in the main, poor, and they were not in accord with the municipal authorities in the matter. The question of cost, therefore, largely entered into consideration at that time, and the minimum of insulation was employed. In view of the good showing demonstrated in the statement quoted, it is to be regretted that the various changes in the methods of operation of underground circuits for electric light and power during the past twelve or fifteen years involved displacing the majority of the smaller cables employed in the early days by cables of larger cross-section and thicker insulation. Hence, the longer experience that might otherwise have been gained as to the durability of these cables is not available. But with the experience obtained in New York, added to that quoted by Mr. Clark, a certain meed of confidence might now, it would seem, be placed with safety in the durability of properly made and laid underground cables.

From Other Points of View

Selecting Material for Hydraulic Machinery

Arthur Falkenau, before the Franklin Institute

IN every construction the expense is to be considered, and this frequently determines the choice of cast-iron or steel castings for hydraulic cylinders. At times extreme high pressures indicate the desirability of using steel forgings for cylinders. If the cylinder is to receive a plunger which can be packed externally, cast-iron or steel castings prove very satisfactory, but where a piston is to operate in the cylinder, on account of the wear of the leather packing, a forged cylinder, bored

and ground, gives the best results. With castings a copper lining is frequently resorted to in order to present a smooth surface to the leather.

A most important consideration is the density of the material, entirely aside from the tensile strength. Water under 3000 or 4000 pounds pressure will ooze through cylinder walls made of ordinary gray iron 3 inches to 4 inches thick, that is, if it is open-grained iron. For these high pressures it is usual to use air-furnace iron, which, besides giving a tensile strength of 30,000 to 32,000 pounds, furnishes a very dense material, and now that steel castings are so much more reliable than formerly, steel castings are supplanting the air-furnace iron.

In this connection I would say that in my experience, however, I have known air-furnace iron to fail where a good ordinary casting was successful. This was largely due to the manner of the casting and local shrinkages from gates and risers. The failure of cylinders or valve body castings to be thoroughly impervious to the water is frequently the cause of great annoyance and expense in the construction of hydraulic machinery. I have had cases where on account of the anxiety of the customer to obtain the machine we have had to pass cylinder or valve bodies which when first tested failed to hold the pressure, the water oozing through the walls quite rapidly. We remedied the defect by pumping starchy fluid prepared from potatoes into the cylinders, and after half an hour to an hour's work, the cylinders were bottle-tight. These cylinders were put to work under a water pressure of 1500 pounds, and they have remained permanently tight. I designedly use the word "water-tight," as a later experience proved to me that the starch-caulking method is not oil-tight. In building some 200-ton pressure machines with 10-inch cylinders we used cupola-iron castings. As they proved defective, we next ordered some of the air-furnace iron. After trying three of these, all of which proved defective, in order to meet the importunities of our customers, we concluded to try the starch-caulking method. Within a half hour the cylinders were perfectly tight, and after having a hydraulic pressure of 400 pounds per square inch applied to them, and locking this pressure in the cylinder, a drop of only ten pounds was recorded after twelve hours. We thought that our annoying problem was solved, and expedited the machine to the customer's work. The next morning we were informed that the cylinder was leaking badly, and, on inspection, found that our customer was using oil, and that the oil oozed through the cylinder at an apparently greater rate than the water had done originally. I suppose that the oil must have had some dissolving effect upon the starch. As we had had such unsatisfactory results with the air-furnace iron, I concluded that the only rapid solution of our trouble would be some other way of sealing up the pores of the cylinder. As the leak indicated, the porosity was mostly at the bottom of the cylinder. We, therefore, had the inside of the cylinder towards the bottom brazed by the ferrofix process. This proved entirely successful, and the cylinder has remained sound ever since. I understand that in the case of steel cylinders the sealing by means of the thermit process has been successfully used.

It may be interesting to note here that in the year 1849 the first cylinders used in the hydraulic presses constructed for raising the tubes of the Brittania bridge into position proved porous and leaky, and were made tight by pumping out meal gruel and sal ammoniac into them. These cast-iron cylinders were 20 inches in diameter and had walls 8¾ inches thick. When they failed, they were replaced by cylinders made of wrought iron with 8-inch walls.

When the wrought-iron cylinders were first put to work, the engineers were discouraged, due to the fact that the cylinders expanded under the great pressure, causing the pistons to leak. New pistons were made, but the expansion continued. The outer diameter, however, remained constant, and this encouraged the engineers to persist in making new pistons until the inner portions of the cylinders had taken a permanent set.

In valves and pumps where water under high pressure attains a high velocity, it has been a general experience that cast iron and steel are frequently subjected to a peculiar cutting action. According to my own observation, this cutting action has been decidedly more rapid and marked when two dissimilar metals were in contact; thus, in some valves which we built, we originally used steel valves and bronze bodies. In several instances, after a year or two, we found the steel valve apparently eaten out as if by an acid. In one particular instance, believing that acid or grit in the water was the cause of the trouble, a water filter was put in place and only pure filtered water was used throughout the system. The new steel valves were soon eaten as badly as the former ones. It may be that some tannic acid, washing out of the leather packing, had something to do with this action, or the action may be of an electric nature. We replaced the steel valves by bronze ones, so that two like metals were in contact, and no further trouble was experienced. I have examined samples showing this peculiar pitting action, which, as the location showed, could not have been caused by the impact of the water, due to high velocity in passing out of the valve. Still, the fact that this action occurs near the point of efflux, and not so much elsewhere, might lead one to discountenance the electric couple theory. This peculiar action, I believe, has been observed by a great many engineers, but does not seem to have been satisfactorily explained. For small structures under high hydraulic pressures, say from 3000 to 8000 pounds, forgings are far more satisfactory than castings, and I have found bronze under these high pressures unsatisfactory solely owing to the low or uncertain elastic limit of the same. The castings seem to gradually expand and get leaky, although figured with the factor of safety of 6 to 10 based on the ultimate strength.

Compressed Air Uses in a Shipyard

James L. Twaddell, before the North-East Coast Institution of Engineers and Shipbuilders

WE have had a compressed air wood deck caulking machine, and we are now caulking a ship's teak deck with it, and it is doing excellent work. As compared with the ordinary style of hand-caulking, we find,—to put the case very fairly indeed,—that in the hands of one man it does the work of four easily, but in many cases we have had far more than that out of it. In regard to the wood deck planing machine, that also emanated from our works, and it is a complete success. It is a much better machine than the electrical one, and the exhaust air clears its own track by blowing away the chips from the deck. As compared with handwork, there is no comparison at all. With the pneumatic machine you get a surface almost like that of a billiard table, whereas you get no regularity with hand-planing unless you go over it very often.

We have also used pneumatic tools for distributing ground cork on the surfaces of war vessels, and also in covering the cork surfaces with paint, which takes a very great deal of hand labour when done with the brush. By distributing it with the compressed air the paint is put right into the rough surface with one coat,

and the compressed air device does not use any more paint. It is a simple contrivance, something like an ejector.

We have found in many instances that compressed air can be used instead of steam. For instance, we have had lying at our finishing jetty a vessel with auxiliary machinery on board, but no steam near. We have applied the pneumatic power to auxiliary pumps, simply coupling up the compressed air and using it instead of steam. By this means we have also run an electrical plant all night. I mention this only to show the various uses that compressed air can be put to. In fact, the more I see of its usefulness the more I am surprised it has been so long in coming, and that so few have taken it up now it has come. I consider the adoption of pneumatic plant in shipbuilding yards one of the finest things that has happened during the last ten or fifteen years in shipbuilding. It is a matter of such wide interest that people have only got to see it to be convinced of its utility.

Alcohol Engines

Professor Elihu Thomson, before the U. S. Congressional Ways and Means Committee on Free Industrial Alcohol

GASOLINE as well as kerosene has the great disadvantage that it floats upon the water and is distributed by water. It is a well-known fact that it is commercially useless to attempt to extinguish burning gasoline or kerosene by water alone. The use of water may, in fact, be a positive disadvantage in floating the burning material over considerable places in spreading fire. Not so with alcohol, which mixes with water in all portions, and which is at once diluted and prevented from remaining combustible.

We have recently tested at the Lynn works of the General Electric Company a Deutz alcohol engine, a type of engine made in Germany especially for use with alcohol, and the results have been such as to prove without doubt the entire suitability of alcohol, if cheap enough, as a fuel for internal combustion engines. This particular engine is to be sent to the island of Cuba and coupled to a dynamo for lighting. It will be operated with the cheap Cuban alcohol, which is, I am informed, sold there at about 12 to 15 cents per gallon. A few gallons of this alcohol were obtained and used in our tests here, and it was found to be a high-grade spirit, containing 94 per cent. alcohol by volume and 6 per cent. of water, or about 91 per cent. alcohol by weight.

It may be mentioned here that our experiments developed the fact that alcohol is suitable as a motor fuel even when it contains as high a percentage as 15 per cent. of water. Notwithstanding the fact that the heating value of alcohol, or the number of heat units contained, is much less than in gasoline, it is found by actual experiment that a gallon of alcohol will develop substantially the same power in an internal combustion engine as a gallon of gasoline. This is owing to the superior efficiency of operation when alcohol is used. Less of the heat is thrown away in waste gases and in the water jacket. The mixture of alcohol vapour with air stands a much higher compression than does a mixture of gasoline and air without premature explosion and this is one of the main factors in giving a greater efficiency.

The exhaust gases from the alcohol engine carry off less heat. They are cooler gases. It is well known that the exhaust gases from a gasoline of kerosene engine are liable to be very objectionable on account of the odour. In our tests of the Deutz alcohol engine there was absolutely no such objection with alcohol fuel, the exhaust gases being slightly odorous, or nearly inodorous, but

what odour there was, was not of a disagreeable character.

There is just now the beginning of a large development in the application of the internal combustion engine to the propulsion of railroad cars on short lines as feeders to the main lines. In this case an ordinary passenger car is equipped with a power compartment at one end, in which there will be installed an engine of, say, 200 horse-power of the internal combustion or explosion type. The growth of such a system is liable to be hampered in the near future by the cost of gasoline as a fuel, and the difficulties of using kerosene are still quite considerable. Especially is the exhaust likely to be offensive. In this case alcohol, which could be produced in unlimited amount, could be substituted.

It may be mentioned, in conclusion, that the efficiency,—that is, the ratio of the conversion of the heat units contained in the fuel into power,—is probably higher in the alcohol engine than in engines operated with any other combustible, and doubtless, on account of the comparative newness of the alcohol engines, there is still room for improvement in this respect.

A Point in Boiler-House Construction

W. H. Booth, in "Power"

I ONCE came across an instance of a man in charge of a blowing engine, who, finding his engine-room somewhat draughty, boarded up the air inlets and nearly shook the building to pieces before he was found out and put right.

How many poor draughts in steam plants may not be somewhat similarly caused? Stand at either end of a long boiler house, with the doors open, and there will be a strong current of air flowing in at each end. If the boiler house is one of the more modern abominations, this air current becomes simply a winnowing force, carrying all the fine dust forward, so that, excepting at the end boilers of a row, there is all the time a dust-laden breeze travelling toward the middle boiler. In a house of twenty boilers a little calculation will show that there may easily be 3000 and 3600 cubic feet of air per second required to supply the fires. If all this must come in at one door, opened, say, 15 feet by 15 feet, the velocity of the air will be 20 to 24 feet per second through the door. One never sees a boiler house where there appears to have been any real attention paid by the designer to the problem of air entrance. There are often louvers in the so-called ventilator roof, and these louvers are primarily intended to increase comfort by allowing heated air to escape. It is doubtful if they do often act in this way, and it is far more likely that they serve the very necessary purpose of admitting air to the furnaces. One thing is certain, it is bad practice to admit air by the end doors, for this promotes dust which is raised by the strong and rapid draught and cannot again settle down, but is carried forward to render the boiler house dirty and the duty therein disagreeable.

It would greatly reduce the velocity of air currents at every section were provision made by small air inlet openings to provide the necessary supply to each boiler through a grating from below. Ventilation is often advocated to be downward in direction, and there appear good reasons to believe that an air supply should be admitted above the level of the boilers, and it is clear that if the grate surface of the boilers is, say, 10 feet per foot of boiler house length, such a provision would be ample, or more than ample, for such a grate area, seeing that of any grate area never less than half is occupied by bar surface and of the remainder the passage is more or less barred by fuel. Or we may calculate the

actual air velocity through a given opening on the assumption of 2 tons of coal per hour in a double-banked house per 15 feet of length, or, say, 5 pounds per foot of length per minute, which may represent approximately 20 cubic feet of air per second per foot run of boiler room. If an entrance velocity of 10 feet per second be permitted, it would be necessary to provide on each side of the boiler house a series of slots 2 feet high and 6 inches wide divided by 6-inch pieces; that is to say, half the wall space along a strip of wall 2 feet wide. Whatever may be done, intentional provision for air should be made and its entrance should not be left to fortuitous openings.

The High-Voltage Trolley

From the "Street Railway Journal'

ONE of the striking features of European single-phase practice is the tendency toward higher trolley voltages, compared with which 3300 volts seem low. The early roads, like the Stubaithal, were installed with a 2500-volt trolley. This was increased on the Blankenese, and one or two other roads, to from 6000 to 6600 volts. Then followed a Swiss installation of the Oerlikon Company, of 15,000, and the Siemens-Schuckart Company is now experimenting with 20,000 volts for use on the Swedish Government Railways. Nor have direct-current advocates been silent on this question of high voltage. Mr. Sprague's belief in the practicability of 1500 volts is well known, and Max Deri, a prominent European designer and engineer, has gone on record in favour of the practicability of building a direct-current motor of the interpole type which could be operated on voltages between 2000 and 3000.

It is not our purpose here to discuss the relative merits of these different proposals, but to point to the marked tendency toward much higher trolley voltage both in alternating-current and direct-current systems, and also to direct attention to two points in the 15,000-volt system of the Oerlikon Company, which has been in operation long enough to demonstrate its feasibility. One is that both the Ward-Leonard scheme of conversion to direct current on the locomotive, and the regular commutated single-phase motor construction have been given steady work, and that neither locomotive, despite the high voltage used, has given any trouble in the matter of insulation. The other is, that though the Ward-Leonard locomotive would appear to involve very considerable extra weight, it is an open question whether, with thoroughly modern design of the direct-current apparatus and a given draw-bar pull and speed, the weight of a commutating single-phase equipment would not be nearly as great. Comparative data from these two types of locomotive would throw a great deal of light upon the questions of heavy electric traction, and until we do get them, or the first of the New York, New Haven & Hartford locomotives starts up, we shall still have to rely on computations and guarantees.

The successful use in Switzerland of 15,000 volts on the trolley wire, is a sufficient demonstration that the employment of such voltage is not open to any very grave objections. The catenary construction, with long spans from the bridges, seems to ensure a very reliable system of working conductors. Collection of current at high voltage no longer has any special terrors for the engineer, and with the small current required, it becomes entirely feasible to work very long sections of road from a single power house, and the cost of the distribution system becomes absurdly small. One power station per hundred miles of line is then entirely feasible, while using the trolley wires alone for the transmission, and the operation of a long line from hydrau-

lic powers becomes a comparatively simple matter.

Without passing beyond line pressures now known to be entirely practicable, one could thus operate the whole New York Central system from New York to Buffalo without burning a pound of coal for motive power. It may be many a year before this feat is seriously undertaken, but the days of low voltage are surely numbered. It will not be so very long before we shall look back upon them as upon the atmospheric engines of a century ago. A few daring experiments will show the way, and then the world will fall into line, as it has many a time before "when the thing that couldn't happen has occurred." The use of hydraulic power for transportation is an end greatly to be desired, for the world needs the coal, what is left of it, for other purposes,—keeping warm, for example.

At the present rate of consumption, it will not take many years to put the price of fuel where it will have to be used very sparingly. It is, therefore, particularly interesting to record anything that can delay a day so uncompromisingly cheerless. With the Oerlikon experiment going on, and with the tests with high voltages now being conducted for the Swedish Government, it looks as if the Continental engineers were keeping up their end of the good work. Another year will certainly bring a rich store of experience in the performance of single and three-phase locomotives. It has taken some years of experiment to work up to this point, but progress hereafter should be more speedy.

New Electric Incandescent Lamps

Dr. Louis Bell, before the Association of Electric Lighting Engineers of New England

DR. BELL pointed out the need of smaller arc lighting units or their equivalent in high-efficiency lamps, and then sketched the German researches upon elements with high melting points in the quest of new filament material. The efficiency of a light producer depends almost entirely upon its temperature. Tantalum was found to be hard, ductile, of a higher specific resistance than platinum, and attacked only by hydrofluoric acid. It is almost infusible, had formerly been obtained only in the form of a black powder, and had to be melted in vacuo in the electric furnace before it could be used for filament work, Dr. Bell described the tantalum lamp and exhibited one of 22 candle-power to the association in operation. Tests which Dr. Bell made upon a number of tantalum lamps showed an average consumption of about 2 watts per candle-power, and a life of 800 hours on direct current. With a 22-candle-power tantalum lamp a wattmeter revolves only two-thirds as fast as with an ordinary 16-candle-power lamp. On alternating-current circuits the results are somewhat less favourable. After about 200 hours the filament gets brittle, and tends to draw tight a little quicker than does the ordinary carbon filament. Such lamps would not be used in service where there is much vibration. They cost about $1 abroad, and at any price above 5 cents per KW.-hour are cheaper than the ordinary incandescent, even if the latter is renewed free of charge. The filament is still not quite perfected.

Dr. Bell also exhibited an osmium lamp in operation. It had a consumption of about 1 2-3 watts per candle-power. Osmium is so rare that these lamps are rented, abroad, and it is doubtful if they will come into very wide use in America. It exceeds the tantalum lamp in brilliancy and is about 24 candle-power in rating. There is not the same tendency to draw light as in the tantalum lamp. He then discussed the high-efficiency General Electric lamp with a graphitized carbon filament, and predicted that although the effi-

ciency is at present from 2.5 to 2.75 watts per candle-power, it is probable that within a year or two we shall have a 2-watt lamp. The life is good, on the whole, and a 20-candle-power lamp is promised soon. It is a good point that the resistance of the filament is nearly uniform, being almost entirely independent of the temperature. It is hard to get long life and low candle-power in a high-voltage lamp. The advent of the high-efficiency lamp means that a great many more lamps can be installed on the present systems, and if the experience of the past is any criterion, it is probable that the number of new customers will more than pay for the reduction in price per lamp-hour which will follow. In the use of these very efficient lamps lies the opportunity for fighting cheap gas lights. In the brief discussion which followed, the point was brought out that the life of a tantalum lamp on an alternating circuit is only about half that on the direct current.

JOHN CHRISTIAN KAFER

A TRIBUTE OF AFFECTION BY WALTER M. McFARLAND

THE recent death of this talented engineer and splendid man has removed one who played a very important part in the education of many naval officers, especially of those who passed through the separate course for engineers at the Naval Academy. Indeed, all the cadet engineers, except those in the class of 1878, were at one time or another under his instruction.

Mr. Kafer was unusually fitted for the work of instruction, not only by his great natural ability and splendid equipment as an engineer, but, above all, by a generous sympathy with young men which lasted all through his life. Every man who had been fortunate enough to be one of his pupils counted him a personal friend, and many of us who were privileged to keep in close touch with him felt that we were specially honoured when he permitted us to call him Uncle Jack.

Mr. Kafer was born December 27, 1842, so that, at his death on March 30, 1906, he was not yet sixty-four. When not yet quite twenty-one, he entered the navy in 1863, and was constantly "at the front" until the close of the Civil War, taking part in the James River campaign and in the first attack on Fort Fisher. In the natural routine of service he also made other cruises, notably one on the "Tennessee" (1875-8), where he was a close associate and friend of Admiral (then First Assistant Engineer) Melville; but his greatest service to the navy was in his duty at Annapolis and at the Bureau of Steam Engineering. He was one of the first instructors at the Department of Steam Engineering at the Naval Academy when the separate course for engineers was formed, and, altogether, was an instructor for about ten years, broken by the cruise on the "Tennessee."

It is possible that the young engineers of to-day do not realize fully how much credit is deserved by these older men who were the pioneers in technical education. At the present time the equipment of the technical schools and the literature of instruction are so complete that the personality of the instructor may almost be considered to occupy a secondary place. It was quite different with the men who were instructors in the

sixties of the last century. There were practically no text-books, and their courses of instruction had to be made up largely from their own experience and from their digest of technical literature. That they did splendid work is shown by the men who were turned out under such a course. Besides Mr. Kafer, the early corps of instructors in steam engineering at Annapolis included such men as Dr. Robert H. Thurston, Professor David M. Greene, John D. VanBuren, Charles H. Manning, William L. Nicoll, David Jones, Robert Crawford, George W. Roche, Frederick Shober, Thomas W. Rae, and John Pemberton. Of those who were peculiarly identified by long service with the course, only Mr. Manning and Mr. Crawford remain. In connection with his work as a teacher, it should be mentioned that Mr. Kafer was invited, in 1885, to become the Dean of Sibley College, at Cornell University, but his health would not permit him to accept.

Mr. Kafer was principal assistant to Engineer-in-Chief Loring, and also for a short time to Engineer-in-Chief Melville, to both of whom he was not only an able assistant, but the most loyal of friends. This service covered the last of the old and the beginning of the new navy, and in this work Mr. Kafer had a very prominent part. His health had not been good for many years, and, indeed, during a considerable part of his cruise on the "Tennessee" he stood watch on crutches on account of varicose veins in his legs, which made it almost impossible for him to keep on his feet for long periods. In March, 1888, he was retired on account of his physical condition, and the navy thereby lost the active service of one of the finest men who ever held a commission, although it did not lose his heartfelt interest and active sympathy in every movement looking for an increase of efficiency.

After leaving the service he was a consulting engineer for a time, and then became general manager, and later vice-president, of the Morgan Iron Works, in New York, which position he held for a number of years, until his desire for improvement of the plant, which was prevented by divided ownership of the stock, led to his severing his connection. For a time he was vice-president of the Quintard Iron Works, at New York, but his health was such that he could not tie himself down to any position which required uninterrupted service, and he, therefore, relinquished this also. Very recently he formed a partnership with Messrs. Mattice and Warren, former pupils of his at Annapolis, and they had opened offices in New York as consulting engineers.

Mr. Kafer took a very active part in the technical societies connected with engineering. He had been a member of the board of managers and vice-president of the American Society of Mechanical Engineers, and was a member of the council of the Society of Naval Architects and Marine Engineers from its beginning. He attended the meetings whenever practicable, and contributed materially to the value of the proceedings by taking part in the discussion of papers. At the Engineering Congress connected with the Chicago Exposition in 1893, he was one of the most active members of the Division of Marine Engineering and Naval Architecture, of which his old chief, Admiral Melville, was the chairman. He was also the first American member of the Institution of Naval Architects of Great Britain, having joined very soon after the foundation of that society.

If he had done nothing more than the work which has been briefly summarized above, he could have looked upon his life as well spent and very useful; but besides this he was for many years the most active spirit in the Engineers' Club, of New York, which has become, possibly, the greatest factor of what might be

called the social side of engineering. He was one of the earliest members of the club when it occupied quarters on Twenty-ninth Street, and it was due almost entirely to his courage and persistence that the club moved to its present fine quarters on Fifth Avenue. He was chairman of the house committee when the removal occurred, and was chiefly responsible for the adaptation of the building to club purposes. He was president of the club from 1901 to 1904, and had been for many years one of the board of governors.

For some years he had realized more fully than, perhaps, anyone else, that the growth of the club would compel it to seek new quarters, and preferably in a building of its own. At his own risk he secured options for the splendid site on West Fortieth Street, facing Bryant Park, where the beautiful new home of the club, the gift of Mr. Andrew Carnegie, is now under erection. The building of this new club house was very near his heart, and he had been, from the start, the treasurer of the building committee, and was giving the work of supervision a very large part of his time. He was also treasurer of the building committee of the United Engineering building, on Thirty-ninth Street, another of Mr. Carnegie's gifts. In fact, he was Mr. Carnegie's representative in the financial side of these undertakings. He was not spared to see their completion, but those who know the part which he played will always feel that the new Engineers' Club is a monument to him.

With all his amiability and sympathy, Mr. Kafer was a man of very strong character, and one whose courage in any cause which he championed never faltered. In the old days of the unfortunate Line and Staff fight in the navy, he was one of the foremost champions of the cause of the engineers; but it is very pleasant to note that so reasonable and conscientious was he in all his efforts that he enjoyed in the highest degree the respect and confidence of his brother line officers, many of whom were among his intimate friends.

Within the past year a number of his friends and admirers in the Engineers' Club purchased a fine portrait of him by one of the foremost artists in New York and presented it to the club. A reproduction of it is printed in this issue. It is pleasant to think that this evidence of the affectionate regard in which he was held came in time for him to enjoy it.

A touching tribute came, on the day of his death, in the form of a telegram from that beloved old man and famous engineer, John Fritz, now in his eighty-fifth year, to the club, saying:—"I sincerely sympathize with you all in the loss of John C. Kafer. We have lost a dear friend, the club a valuable member, the country a good citizen and a useful man."

As a personal friend, he was ideal. His attractive personality, lovable disposition, broad sympathy and tactfulness drew men to him, so that his companionship was always a pleasure, and any gathering that included him was the more genial and successful for his presence. His kindness and encouragement to younger men meant a great deal to them, and those who knew him well will long feel a heartache at the loss of Uncle Jack. No words of praise can adequately express the love which his friends bore him, but it can be truly said that a most lovable, high-minded, and public-spirited man, as well as an accomplished engineer, has passed away, leaving a record which all may cherish and which is without a stain.

PHOTO BY BUTLER, BROOKLYN, N. Y.

DR. SAMUEL SHELDON

THE NEWLY ELECTED PRESIDENT OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

SEE PAGE 277

CASSIER'S MAGAZINE

VOL. XXX JULY, 1906 No. 3

THE LATEST ORE-HANDLING MACHINERY ON THE GREAT AMERICAN LAKES

By Day Allen Willey

DURING the past ten years no less than 140,000,000 tons of iron ore have been taken from the ranges adjacent to Lake Superior and transported to the furnaces in the Pittsburg district, the Ohio Valley, and elsewhere. During the shipping season of the year 1905 over 35,000,000 tons were brought down from the Superior ranges.

These figures are of such magnitude that the extent of the industry can scarcely be appreciated. It is due entirely to the remarkable development which has been attained in machinery for excavating the ore, unloading the ore carriers, and for serving the furnaces. By using mechanical unloaders and conveyors the cost of transporting a ton of iron ore from Duluth, for example, to Conneaut has been reduced from $3 to 60 cents. A ton of ore loaded on cars at any of the principal ranges costs but 70 cents, representing the work of excavation. Twenty years ago the price per ton for unloading and piling the ore was between 50 cents and 75 cents, with the mechanism employed at that time. At present the cost ranges between 15 cents and 18 cents, making the total charges for mining the ore, loading and unloading vessels and for water transportation less than $1.50 per ton.

The September, 1900, issue of this magazine contained an article which summarized what had been accomplished in the invention of ore-transferring machinery up to that time. Since then the enlarged capacity of the ore-carrying vessels and the improvement in apparatus for unloading them as well as the increase in the size of ore cars, have practically revolutionized the industry so far as mining and transportation are concerned, for the shipments during 1905 were fully double the tonnage recorded in 1899, although this quantity was only slightly less than 18,000,000 tons.

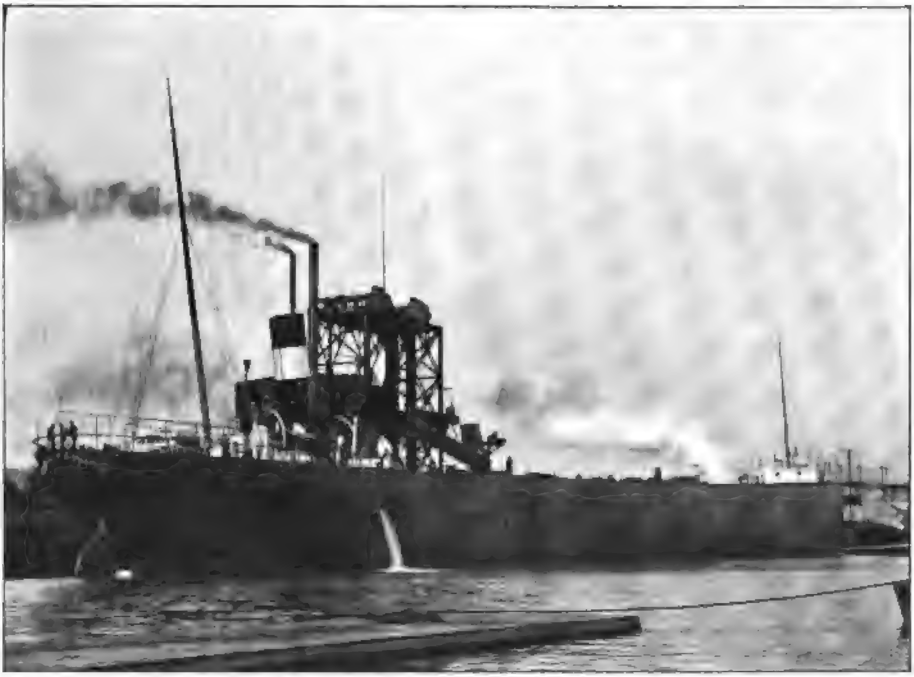
Ore is now shipped from about thirty large docks at ports on Lake Superior and Lake Michigan. The storage capacity of these docks rep-

HULETT AUTOMATIC ORE UNLOADERS AT THE WORKS OF THE LACKAWANNA STEEL COMPANY AT BUFFALO, NEW YORK. BUILT BY THE WELLMAN-SEAVER-MORGAN COMPANY, CLEVELAND, OHIO

resents over 1,000,000 tons, compared with less than 700,000 tons in 1900. The largest cargoes which were transported up to the year in question did not exceed 8000 tons. During 1905 a considerable portion of the material was taken down the lakes in steamers having a carrying capacity of 12,500 tons.

This expansion of size of ore-carriers has been due largely to the increased facilities for loading and unloading. In fact, the rapidity with which ships' holds are filled is almost marvellous. At any one set of docks at Duluth a fleet of fourteen vessels has been filled with 64,000 tons of ore in twenty-four hours, while the steamer "Wolvin," one of the largest carriers, has taken on 12,250 tons in the actual loading time of 1 hour and 30 minutes, being at the dock only three hours in all.

Nowhere in the world is material placed on board vessels as rapidly as at these ore-shipping ports. As an illustration, the Allouez docks of the Great Northern Railway Company near Superior City may be cited. They are three



THE "WOLVIN," ONE OF THE LATEST TYPES OF ORE CARRIER, BUILT BY THE AMERICAN SHIP-BUILDING COMPANY CLEVELAND, OHIO

in number, the largest being 2100 feet long and accommodating vessels on each side, so that four large steamers can take on cargo at once. Ore can be run directly into the holds from the cars or from the storage pockets, which hold 130,000 tons. It is carried by gravity through conduits, which are lowered into the hatches. A force of 50 men only is needed to clean up the cars and pockets, and perform other necessary labour. Adjacent to the Allouez piers are yards where a thousand 50-ton cars can be stored.

The application of the cantilever conveyor for removing ore from vessels inaugurated a new era in the iron industry. In 1881, Alexander E. Brown erected the first "Brownhoist," as it was very appropriately termed. Its advantages over the former methods were so great that in twenty years no less than one hundred plants, comprising 300 machines, were installed at the principal ore-receiving ports on the Great Lakes. While other devices of greater capacity have been added recently, the "fast plant" and the bridge tramway are still extensively used, owing to their convenience and economy.

The bridge tramway is employed where the material is to be removed to some distance from the waterside. It is supported on two towers, mounted on trucks, by which it can be moved up and down the wharf on a track. The outer arm of the tramway projects over the deck of the ship, and upon it moves a trolley from which one or two buckets are suspended. These are filled by hand labour, hoisted to the bridge, thence carried inshore to the car or stock pile, where they are emptied automatically. The outer end, or apron, of the bridge is hinged so that it can be raised to a vertical position

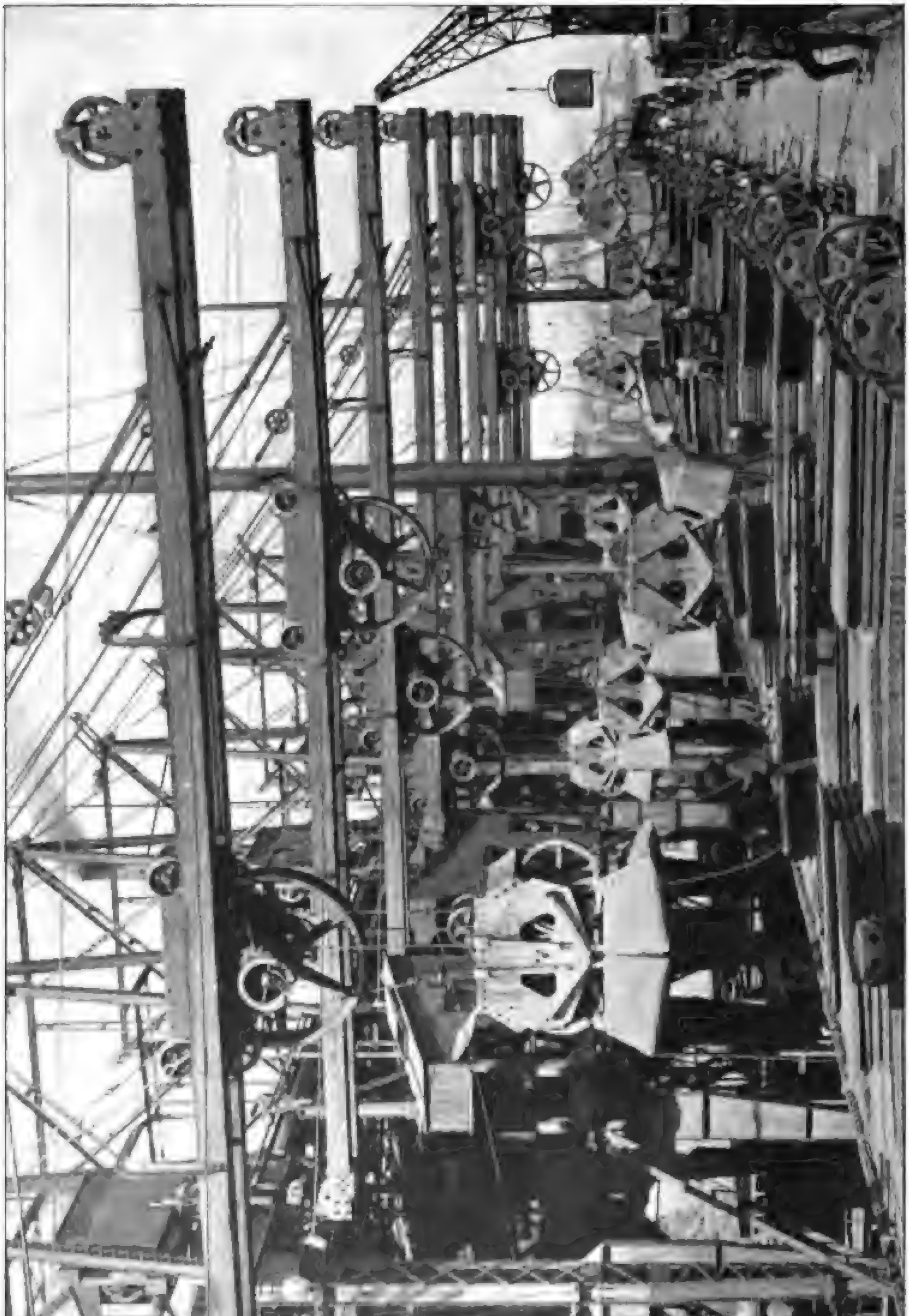
"BROWN HOIST" FAST PLANTS IN OPERATION ON THE PENNSYLVANIA RAILROAD COMPANY'S DOCKS AT BUFFALO, NEW YORK. INSTALLED BY THE BROWN HOISTING MACHINERY COMPANY, CLEVELAND, OHIO

when not in service. The "Fast Plant" type of the "Brownhoist" is merely a single tower, without the bridge extension. It is mounted on rails, and provided with an apron on which the trolley moves in and out. It is used principally to transfer cargo to cars, and its inner arm projects over a series of railway tracks. In addition to the Brownhoist, several other applications of the cantilever idea have been utilized in transferring ore, being driven by steam or electric power. The more notable types of these machines were fully described in the earlier article in this magazine above mentioned.

With the bridge tramways in operation, a problem which presented itself was the construction of a bucket which would be self-filling. It was found that the automatic buckets used for loading sand and other soft material would not work satisfactorily with iron ore. This led to the design of the automatic shovel bucket, which has effected almost as great a revolution in the ore-carrying industry as the Brownhoist, for, by its use, the hold of a vessel is practically emptied without the aid of human labour. It will remove over 95 per cent. of the ore and deposit it on the stock pile or in the cars for transportation to the smelters. These buckets have been enlarged until they have a maximum capacity of about ten tons.

To handle this great

ORE-HANDLING PLANT BUILT BY THE BROWN HOISTING MACHINERY COMPANY FOR THE BUFFALO & SUSQUEHANNA IRON COMPANY AT BUFFALO. THESE MACHINES ARE TYPES OF THE LATEST "BROWN HOIST" BRIDGE TRAMWAYS, ELECTRICALLY OPERATED AND EQUIPPED WITH A MAN TROLLEY CARRYING A 5 TON ORE GRAB BUCKET



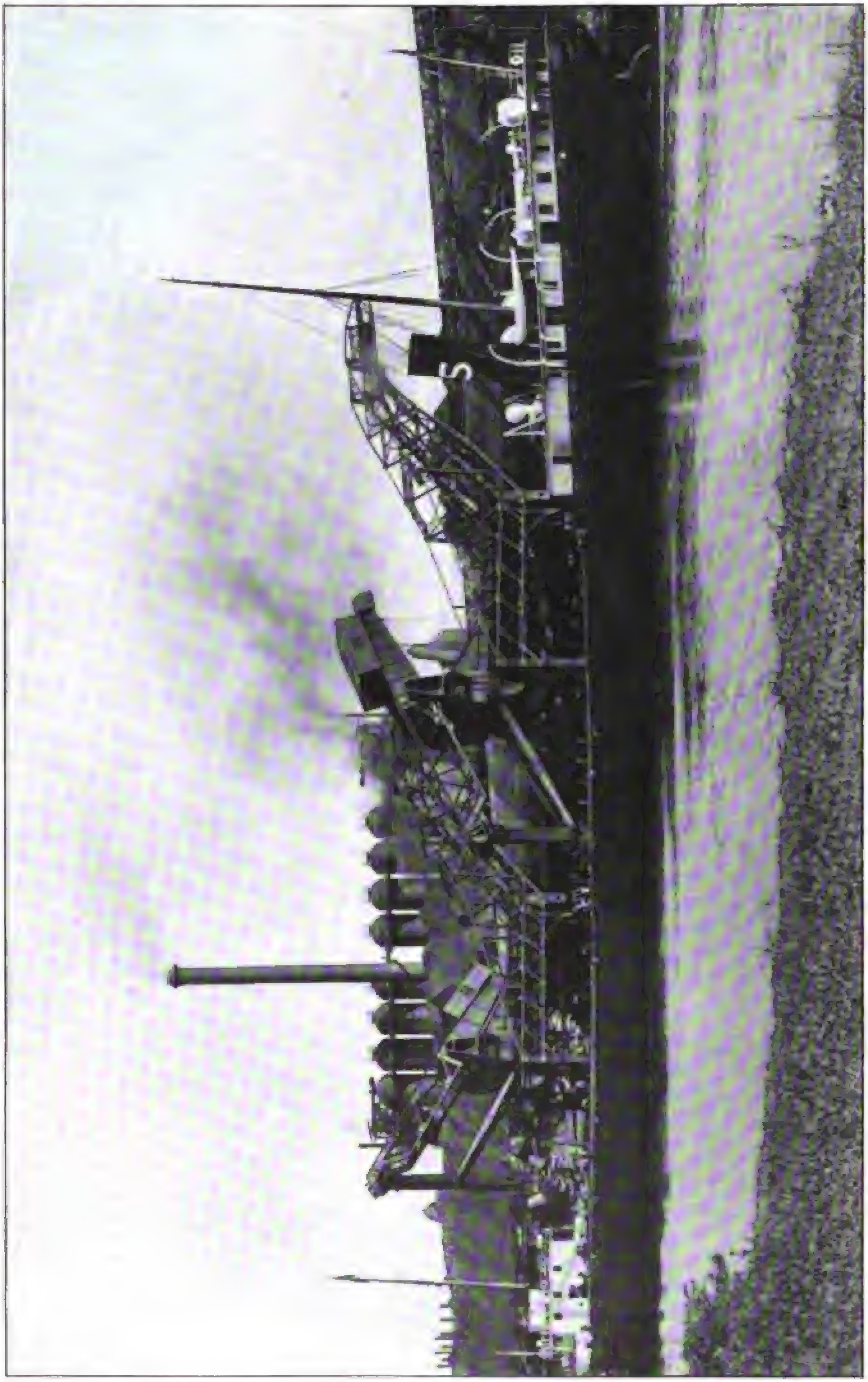
DECK VIEW OF A MODERN ORE STEAMSHIP WHILE BEING UNLOADED WITH HULETT BUCKETS, AT CONNEAUT, OHIO, ONE OF THE GREAT AMERICAN LAKE PORTS

THE LATEST TYPE OF HULETT UNLOADER BUCKET, SHOWING METHOD OF CLEANING UP THE HOLD OF AN ORE STEAMER

weight, the Hulett unloader was built by the Wellman-Seaver-Morgan Company, of Cleveland, Ohio, and placed in service at several of the principal ports on Lake Erie. Although the Hulett apparatus had been introduced in 1900, it has since been combined with the bridge tramway and other improvements, until at the present time it is by far the most capacious unloader in service. Tests which have been made at Conneaut show that a plant of four of these machines at that port have an unloading record of 7257 tons in 4½ hours, equal to 8124 ordinary tons of 2000 pounds each. This is the fastest ore unloading on record. The four machines averaged during the period of unloading 403 gross tons per machine per minute. The largest amount taken out in any one hour by a single machine was 681 tons.

The latest type of this apparatus has been installed at the works of the Lackawanna Steel Company at Buffalo, and is illustrated herewith. It might be called a mechanical cargo shovel, for, in its operation, it is quite similar to the modern power shovel. The bucket itself is opened and closed by specially designed motors. The total spread of the bucket, when wide open, is over 20 feet, and by telescopic motion it can be made to reach, when open, more than half-way from the center of one hatch to the center of another. It also travels lengthwise of the hatch to the sides of the boat. Consequently it can take out a large percentage of the cargo, working merely in one hatchway, where the hull is not divided into compartments.

The leg to which the shovel is attached is, in turn, connected to the beam, which answers to the beam of the ordinary steam shovel. It is piv-



TWO HULETT AUTOMATIC ORE UNLOADERS, ELECTRICALLY OPERATED, AND PROVIDED WITH SPECIAL CANTILEVER EXTENSIONS, PARTICULARLY DESIGNED FOR DELIVERING ORE ON HIGH BANK BACK OF MACHINE. AT THE UNITED STATES STEEL CORPORATION'S NATIONAL TUBE COMPANY WORKS, LORAIN, OHIO

HULETT AUTOMATIC ORE UNLOADERS AT THE LACKAWANNA STEEL COMPANY'S WORKS AT BUFFALO, NEW YORK. ONE OF THE UNLOADERS IS SHOWN IN THE "DOWN" POSITION, AND ONE OF THE BUCKET CARS IS SHOWN DISCHARGING ITS LOAD

A HULETT CAR DUMPER AT THE WORKS OF THE UNITED STATES STEEL CORPORATION AT YOUNGSTOWN, OHIO

oted, however, and mounted upon a massive truck. In operation, the "walking beam," as it is called, is run out upon the truck until the unloader leg, with its bucket, is over the section of ship hold to be emptied. The beam is then lowered until the bucket has reached the material, and then the mechanism controlling the bucket is set in motion. With the bucket filled, the movements are reversed; the beam is raised and moved inward until the bucket is in position to discharge its contents.

The truck frame carrying the walking beam consists of two parallel girders, mounted upon wheels, the girders being installed at right angles to the face of the dock. Between these girders are set hoppers, into which the contents of the bucket are deposited. The material taken out is transferred to railway cars, or to stock piles adjacent to the wharf. Where the ore is to be placed on the stock pile, the bridge tramway is utilized in addition, and is attached to the other end of the unloader, the hoppers being unloaded into the series of buckets which it carries. By means of cable and trolley the ore is distributed upon the stock pile if desired.

The unloaders can be operated either by steam and hydraulic, or electric power. On the steam-operated machines the power is supplied by a boiler of heavy locomotive type and 175 horse-power capacity, which operates a steam pump capable of supplying the necessary pressure water, the hydraulic pressure being about 1000 pounds per square inch. Hydraulic cylinders are used to open, close, and rotate the bucket, to move the trolley and to raise and lower the walking beam. An independent steam engine supplies the power for moving the machine along the docks and for the haulage of the bucket car.

On the electrically operated machines the power is supplied from motors which take their current through sliding contacts, from lines laid along the dock. The motors for operating the buckets are of 80 horse-power, those for hoisting the walking beam are 150 horse-power, for trolleying in and out, 50 horse-power, and for operating the bucket car and moving the machines, 260 horse-power.

In spite of its capacity, the mechanism is so compact that only three operators are required for each unloader. The bucket operator, who rides into the hatch and out over the dock with his bucket, controls all motions of the machine, except travel from hatch to hatch and operation of the bucket car, his position in the bucket leg enabling him to watch the work to best advantage. Another operator is required for moving the machine from hatch to hatch and for controlling the bucket car. On the steam-operated machines a fireman also is necessary. On the electrically operated machines an extra man is usually provided for oiling and adjustment.

At the works of the Lackawanna Steel Company a single unloader will remove cargoes of ore at the rate of nearly 300 tons an hour, taking out 95 per cent. of the cargo without the assistance of hand shovellers; but, as already stated, 8000 tons have been handled in 4½ hours. A series of twelve "fast plant" unloaders in 1900 handled 6000 tons in 9 hours,—an average of less than 60 tons to each machine per hour. These figures help to give an idea of the great increase in capacity of the latest type of ore-unloading apparatus, as compared with that in use five years ago.

In serving the furnace plant, notable changes have also been made. Where the furnace stack is charged mechanically, the ore may be transferred by means of the bridge tramway and loaded directly from the stock pile into the charging cars. Where the ore is brought to the furnace by rail, however, the Hulett

UNLOADING AND DUMPING ORE ON STOCK PILES BY THE LATEST TYPE OF HULETT CONVEYOR BRIDGES INSTALLED BY THE WELLMAN-SEAVER-MORGAN COMPANY, OF CLEVELAND, OHIO, AT THE WORKS OF THE DETROIT IRON & STEEL COMPANY, AT DELRAY, MICHIGAN

car dumper is now being utilized at a number of the larger steel works. The car dumper has a rotating cradle supported in a rectangular framework on which the loaded railway car is pushed by what is called the "mule car." By means of revolving mechanism the cradle is inverted, carrying the car with it. The top of the cradle forms a chute for directing the material as it flows out. It is, of course, necessary to clamp the car to the cradle, and this is done by an automatic counterweight device.

The mule car is provided with a flexibly connected pusher for engaging the bumpers of railway cars, being so arranged that it automatically adjusts itself to all unevenness of track due to curves. The mule car runs on a pair of narrow gauge tracks between the rails of the standard gauge, and, after pushing the loaded car on to the cradle, runs back down the incline, disappearing into a pit at the foot of the incline, so that loaded cars can pass over and in front of it. It is provided with a powerful friction stop to relieve the impact when it drops into

LOADING BIN FILLING CARS WITH ORE BY A HULETT BUCKET. THE BUCKET HOLDS TEN TONS, AND IS WORKED ELECTRICALLY. THE LACKAWANNA STEEL COMPANY

the pit, and hence allows greater speed of manipulation, as it requires less attention from the operator and automatically stops inself in the pit.

After the loaded car has been placed on the cradle of the machine, it is moved over to the side and against suitable supports on the cradle. As stated, it is not necessary to clamp the car independently, as this is automatically done by counterweight clamps which operate simultaneously with the inverting mechanism of the car dumper.

The cars are inverted to such an angle that all the contents run out freely, and when the car is emptied and righted, the clamp beams release it so that it stands entirely free. The next incoming car bumps the empty one and starts it down the discharge track, when it leaves the machine and yard by gravity tracks and spring switches.

Another type of the Hulett car dumper is movable, propelling itself along the dock or edge of the stock yard. It consists of a framework substantially the same as used in the other types of car dumper, except that the whole machine is mounted on moving trucks which are connected to the necessary propelling machinery. The approach and receding tracks are also mounted on moving trucks and arranged to connect with standard-gauge railroad tracks at any point where the machine may be stationed.

Where such machines are used,

PILING UP ORE FROM ORE VESSELS AT THE LACKAWANNA STEEL COMPANY'S PLANT AT BUFFALO BY HULETT CONVEYOR BRIDGES WITH TWO-PART AUTOMATIC BUCKETS, EACH HOLDING 7 TONS OF ORE. LENGTH OF EACH BRIDGE, 374 FEET

the ore arrives at the furnace in either gondola or hopper-bottom cars. The car dumper dumps the ore from the railway car into four bridge-cars, which are mounted on tracks on a transfer car, the tracks on the latter being at right angles to the standard gauge tracks on which the transfer car travels. After the railway car has been inverted in the car dumper, and the ore dumped into the bridge cars, the transfer car is pushed out from under the car dumper by a locomotive, which at the same time pulls in another transfer car with empty bridge-cars. The locomotive then leaves the empties and shoves the loaded cars up to and opposite the incline approach of the ore bridge.

It is not necessary for the locomotive to wait to place the car accurately, as the bridge is provided with a shifting gear which moves the transfer cars until the tracks on the bridge incline are in line with the short tracks of the transfer car, when the operator, by dropping a lever, connects the rails on the transfer car with the rails on the bridge, and a continuous track for all four cars is obtained. An operator attaches a haulage rope to each bridge car in succession and it is pulled up the incline and out over the stock pile.

The bridge cars are side-dumping, and can be automatically dumped at any point desired, by means of a movable tripper placed on the track. After dumping, the car automatically closes and latches itself and is returned down the incline to its original position on the transfer car. The contents of each bridge car are equivalent to 20 gross tons of ore, so that the four of them will readily receive the contents of the largest railway car, or of two of the ordinary 40-ton cars. The capacity of each of these conveyor bridges is from 400 to 500 gross tons per hour under ordinary working conditions.

The conveyor bridge is constructed with a separate track hung underneath the floor beams. On this track runs the trolley wagon operated by cables on separate drums located in the main tower of the machine. The trolley wagons and machinery are designed to operate either an automatic bucket or a drag bucket. The capacity of the drag bucket is 10 tons, while the automatic bucket for the same bridge will hold 6½ tons of ore. By the use of either one of these buckets the ore is picked up from the stock pile and carried back. The cantilever of the bridge extends over the bins of the furnace, and the ore from the buckets is dumped direct into the bin, or into a bin-filling car, as desired. The capacity of the bridge when taking ore from stock ranges from 700 to 800 tons per day of ten hours.

It is customary to operate the Hulett bridges electrically. The machinery for doing this comprises two 130-horse-power reversible motors, which operate the bridge-car haulers and bucket-operating drums. The car-haulage drum is of two diameters, 5 feet and 8 feet, respectively, so arranged that the haulage rope is wound on the smaller drum while the car is being pulled up the steeper part of the incline; and when the car reaches the more level part of the track, the rope, by means of a spiral groove, passes to the 8-foot drum, which gives greater speed. The drums for operating the buckets are 5 feet in diameter. Heavy friction clutches and powerful band brakes for each drum are provided. With the exception of the car-haulage clutch and brake, which are thrown by hand wheels, the clutches and brakes are all operated by compressed air supplied from an auxiliary compressor system.

For moving the bridge back and forth along the stock yard, power-driven mechanism is supplied, connecting both the machinery tower in front and the shear leg at the rear. The driving gear for this moving mechanism is located on one end of the intermediate shaft. The connecting gear is operated by a jaw

clutch and is bronze bushed for running loose on the shaft. Branch shafts for connecting all the trucks of machinery tower and shear legs are driven from this gear. The moving mechanism is provided with a gravity brake powerful enough to slip the wheels. This brake is a distinctive feature, and is so arranged that it locks the machine in any position when not in operation.

The trolley wagon for this type of bridge has a power wheel 82 inches in diameter and two bucket-hoisting spools, 27 1-3 inches in diameter, increasing the hoisting power at the trolley in the ratio of three to one. This system reduces the rope pull throughout the bridge and at the drums in the machinery tower, securing also a saving in cables, as the ropes which run to the bucket, being the ones most quickly worn out, are comparatively short lengths and easily replaced; while the main hoist and traversing cables do not in any way come in contact with the ore, and, being arranged with large-diameter sheaves, are correspondingly long-lived. The bucket car haulage mechanism is arranged to dump one car at the extreme end of travel and return it to the transfer car, making a complete cycle in one minute. The vertical hoisting speed for drag or clamshell bucket is 175 feet per minute, and the cross-travel, 600 feet per minute, while the bridge travels along its track at the rate of 75 feet per minute.

As already stated, the capacity of the vessels carrying ore on the Great Lakes has been greatly increased in recent years. Their design has also been radically changed, with the view of saving time in taking out the cargoes. As every day a steamer is lying at the dock its expense to the transportation company ranges between $200 and $300, according to its tonnage, time is economized in every way possible. The success of mechanical unloading has been largely due to the method of dividing the hold into compartments, each of which has its individual hatch, and to altering the shape of the interior. The "Wolvin," which represents one of the latest type of cargo-carriers, and one of the largest on the Lakes, was constructed according to this plan; hence a brief description of it may be of interest.

An idea of the size of the steamer can be gained when it is stated that it is 560 feet over all, 540 feet on keel, 56 feet beam, and has a depth of 32 feet. It is built of steel, and in this connection it is a noteworthy fact that it is just twice the length of the first steel vessel built for the Lakes in the year 1887. One of the most interesting features connected with the new vessel is the shape of the hold, which is built in the form of a hopper with sides that slope from the main deck to the tank top, and ends built on the same slope. The continuous length of this hopper, without divisions of any kind, is 409 feet. The width of the top is 43 feet and at the bottom, 24 feet. This form of construction will accommodate the unloading machines by keeping the ore cargo at all times within the grasp of the scoop.

The space between the sides of the hopper and the sides of the vessel is used for water ballast, so that the latter, as well as being in the usual double bottom underneath the hopper, extends up the sides to any height desired. The water-ballast space is divided into compartments by water-tight bulkheads at intervals of about 60 feet. The total water-ballast capacity is 8000 tons. Instead of the ordinary hold stanchions, there is a system of girder arches which support the upper deck as well as the sides of the ship. There are thirty-three hatches with 12-foot centers. Each hatch measures 33 × 9 feet. The hatch covers are opened and closed by machinery.

The vessel carries from 10,000 to 11,000 tons of iron ore on an 18-foot draught. In the coal bunker,

which is located in front of the boiler room, it will carry 350 tons of coal. The vessel has quadruple-expansion engines, located in the after end of the vessel. Mechanical stokers are used, which is in keeping with the policy that no labour that can be done by machinery shall be done by hand. The coal is first fed into hoppers, from which it passes on to travelling grates. The ashes are taken from a point at the rear of the boilers and thrown overboard by means of steam-driven elevators. The boilers are fitted with a system of induced draught.

Tests which have been made in unloading the "Wolvin" show that the self-filling shovel buckets will actually take out 97 per cent. of the ore, leaving only 3 per cent. to be removed by hand labour.

MORE OPPOSITION TO THE METRIC SYSTEM

BY LEADING ENGINEERS AND MANUFACTURERS OF GREAT BRITAIN AND AMERICA

ALTHOUGH for the present the threatened danger of compulsory metric system legislation in the United States is past, its advocates, both here and abroad, are not unlikely to renew pernicious activity at any time. In Great Britain, particularly just now, the workings of the "Decimal Association" will bear watching. Its professed object is the "adoption of a decimal system of weights, measures, and coinage in the United Kingdom," but its real object is the compulsory adoption of the metric system, and of making it illegal and a punishable offence for the inch, foot, yard, pound, ton, pint, gallon, etc., to be used.

As illustrative of what engineers believe who have important manufacturing interests in their care, the following anti-metric communications, received within the past few weeks, additional to those already printed in the May and June numbers of this magazine, will therefore, no doubt, prove of further interest. They are selections from a large number of letters.—THE EDITOR.

From Lieut. Col. E. R. Crompton, Past President of the Institution of Electrical Engineers

I AM not opposed to the introduction of the metric system. I believe that the decimalization of weights and measures and of the monetary system would be a great convenience, but the chief objection to the metric system for lineal measurement is that the duodecimal system of measurement, employing the foot and the inch, is for most mechanical engineering purposes more convenient, more easily remembered, and lends itself far better to the operations of screw-cutting, engine-dividing and the like.

I am in complete agreement with the views of Mr. Billings, Mr. Gingrich and the other American engineers whose opinions are given in your May number. It appears to me ridiculous to ask the two great mechanical engineering nations, America and ourselves, to scrap the enormous plant investment that we now have in measuring appliances, jigs, templates, and the like, based on the inch, for the very doubtful advantage of making our lineal measurements uniform with those of the nations who have only partially adopted

the metric system. I say only partially, for I believe no country has adopted it throughout for screw-cutting purposes.

I find that any loud outcry for the adoption of the metric system in this country is confined to those who describe or analyze existing things, not those who have to design them, standardize them, and group them in convenient sizes for the use of the public.

To the analytical chemist it means little whether it is more convenient to divide sheets by a binary or a decimal scale, but to the sheet roller it is a matter of great importance. Similarly, the analytical chemist, who calls for the metric system, has never stood before a screw-cutting lathe and seen how impossible it is to work with the metric leading screw.

On this point I should strongly advise you to reprint a copy of any table of change wheels of lathes, fitted with metric leading screws, and compare the nomenclature of the various threads cut on those screws by the two systems. You will find that whereas the English standard threads from 1 inch down to $\frac{1}{2}$ inch diameter may be expressed in the very easily remembered form of 8 threads per inch, 9 threads for $\frac{7}{8}$ inch, 10 for $\frac{3}{4}$ inch, 11 for $\frac{5}{8}$ inch, and 12 for $\frac{1}{2}$ inch, it is necessary to name the pitches required for corresponding metric diameters in the clumsy form of the number of tenths of millimetres in the pitch.

From James C. Brooks, President of the Southwark Foundry & Machine Company, Steam and Hydraulic Engineers, Philadelphia

IN my opinion, no law passed by Congress would lead to the adoption of the metric system in our line of manufacture.

If to-day we were given the choice of the metric system or the English system of calculating and notating dimensions upon our work, and the change would not cost us a penny, we would use the English system. It is much easier for calculation and for notation, and the decimals or fractions are fewer. In other words, in putting down dimensions you have fewer fractions to deal with, as multiples of twelve are equally divisible oftener than multinles of ten. You will note that 12 is divisible by 2, 3, 4 and 6; that 24 is divisible by 2, 3, 4, 6, 8 and 12, whereas 10 is divisible only by 2 and 5, and 20 is divisible by but 2, 4, 5 and 10.

In addition to this, when making complicated drawings it is much easier to note dimensions thereon with a fraction than it is with various numerals; or, to make it plainer, it takes up much less room, and, further, the liability to error is much less, as by the metric system a mistake in pointing creates a very great error, and to avoid such mistakes great care must be exercised in calculating.

The writer was formerly a member of the firm of William Sellers & Co. We manufactured the Giffard injector. It was a French invention, and we received our rights from Mr. Giffard to sell it in this country, with an agreement that he furnish us with the drawings of the different sizes. We made our duplicate drawings from the French drawings, and thus started the metric system in that department of our works.

It was my experience that all the draughtsmen in our drawing room, even foreigners who were accustomed, before coming to this country, to the use of the metric system entirely, preferred the English method of measurement and calculation to their own, and were glad to get on other work.

Furthermore, with all this practical experience in the metric system, there was never the slightest disposi-

tion to adopt it in any other department, and, to my knowledge, there was not one member of the firm or officer of the firm who desired it adopted in their department.

No stronger argument can be put forward, in my estimation, in favour of our present system than the fact that, whilst it is entirely legal and permissible to use the metric system, no one in our line of business, to my knowledge, has done so, or expressed a wish to adopt that system. None of my acquaintances or associates who are practical workers consider that it would be more convenient, accurate, or time-saving.

With establishments such as ours, to change all our standards, drawings, tools, etc., would cost a small fortune, and would be a great hardship, inasmuch as we know the new system would entail inconvenience and permanent loss.

From Archibald Denny, of Messrs. Denny Brothers, Shipbuilders, Dumbarton, N. B.

I AM quite opposed to the introduction of the French metre into Great Britain. I have found a general misapprehension as to this matter. Many seem to think that the adoption of the metre is the only possible means of having a decimal system. This, of course, is not so; if desired, our own units could be decimalized.

It is also generally supposed that we have a vast number of tables of weights and measures which are a terrible trouble to children and hindrance in their education. I have seen it stated that by adopting the metric decimal system two or three years of the time of a child's education might be saved. A moment's consideration will show that this is not so, for taking the whole time a child devotes at school to the study of arithmetic, probably in the gross not two years altogether are spent, and only a small proportion of this is devoted to learning the tables referred to.

Advocates for the metric decimal system habitually minimize the difficulty which would be experienced in changing our system. Neither France nor any other country which has officially adopted that system has yet succeeded in doing away with either their old weights and measures for many purposes. So far as the great mass of the population of Great Britain is concerned, they would not benefit at all by adopting that system; on the contrary, they would suffer great inconvenience and loss. Housewives, artisans, and indeed the bulk of the people, use arithmetic for only very simple calculations, and almost invariably work out their results by mental arithmetic. The natural way to divide any number, or thing, is into halves, quarters, eighths, thirds, etc.; but in a decimal system there are only two possible divisors, two and five, and this makes mental arithmetic in that system extremely difficult.

As to engineers, shipbuilders and others who are constantly dealing with figures, they use decimals of a foot, of an inch, of a ton, or of a pound sterling, or any other basis figure, but in doing so they have a wide choice, and use the basic figure which suits best for the moment. They also, for much of their work, use mental arithmetic, and find that vulgar fractions are much more easily handled mentally than decimals.

The expense in adopting a new system would be enormous. All our standards would have to be altered; all our patterns would be useless, also our gauges, and that, as far as I can see, without any corresponding advantage,—indeed, at great inconvenience. In foreign trade I do not

think we would gain anything. Speaking for my own business,—that of shipbuilding,—any foreign inquiries we have are almost invariably in British measures. We have to-day received an inquiry from French friends. The specification is in English, and the figures are given both in the French metre and in the British foot and inch. So far as I can remember, it is only from such small countries as Roumania, for example, that we ever have inquiries in French metres. In the case of countries like Russia, Austria, and Germany, British measures are invariably used. We have found that there is great liability to error in using metric measures; it is so easy to misplace the decimal point, and while, as a rule, the context shows the error, this is not always the case.

Reverting, for a moment, to the taunt frequently thrown at us, that our weights and measures are numerous and nonsensical, it is true that some of the tables we are asked to learn at school are troublesome; but I might say that the ones most troublesome are rarely or never used in general practice. While we have three tables of weights, only one,—that of avoirdupois,—is in everyday practical use with the general public. It is customary to point the finger of scorn at the irregularity of our table of lengths, and special attention is directed to the 5½ yards, one perch or pole. In general practice we use inches, feet, yards, and the mile; with the exception of horse-racing, I do not think we ever hear the word furlong used; in foot-racing, I am sure many of the runners do not realize when they are asked to run 220 yards that they are to run a furlong.

I would point out that British money (which is also a stumbling block to some of our foreign friends), when combined with British weights and measures, is a great convenience. It is usual to sell things at so much per cwt., per ton, per dozen, or per score; in agricultural matters the score is in constant use. It is quite useful to know that 1d. a piece, is 1 sh. a dozen; that 1 sh. a cwt., is £1 a ton, and that 30 sh. a sheep, is £30 a score, and I might go on giving numerous other instances dealing with our different scales of weights and measures.

I may also draw attention to a great advantage our tables possess over the French tables, and that is in the clearness and shortness of the names. Pound, ounce, ton, foot, inch, yard, acre, pint, quart, etc., are much shorter and better than the decigramme and dekagramme, for example, which are long, awkward, and apt to be confused, and I think on this point alone we would loose enormously by adopting the tables of the foreign minority, in which the standard of length is too great, and the ordinary measure adopted, that of the millimetre, is too small.

It is impossible in a short communication to deal really effectively with the question. It would require a volume of no mean dimensions to do that; but the more one studies the question and inquires into what has been the practical result in countries which have officially adopted the metric decimal system, the more one finds that while used by scientists and by the public where required by law, for most practical purposes the old weights and measures are used, and its introduction has simply meant piling another system on the top of the old.

I may say that I was originally a member of the Decimal Association, but left that society when I found that their whole object was the introduction of the French metre. About two years ago I became one of the founders of the British Weights and Measures Association, of which Mr. George Moores, 25, Victoria street, London, is the secretary, to whom I would refer anyone interested for further detailed information as to the disadvantages of the French metre and the advantage of the English units.

From Wigham Richardson, Vice-Chairman of Swan, Hunter & Wigham Richardson, Ltd., Newcastle-on-Tyne

BEFORE replying to your query, I should premise that I do not write in the name of my company. Some of my younger colleagues hold, I believe, different views, which is not at all surprising. They are men of high scientific acquirements, and they are overburdened with calculations, with calculations of every kind, including calculations from the English into the metric, and it is reasonable to suppose that their minds must receive a bias.

No one can deny the advantage, for the purposes of calculation, of a system of weights and measures which conforms to the decimal notation. This has long been recognized. Shipbuilders have always calculated displacements in feet and tenths of a foot, and actuaries calculate in decimals of a pound sterling.

In other respects, however, the metric or decimal system is manifestly inferior to the old units. These are immeasurably superior for the ordinary affairs of daily life which affect the millions of our population and not the small minority composed of the official class and of those who direct large industries.

In my opinion, our established English measures are superior to the metric in every way which affects convenience in the transactions of daily life and also in clearness of perception. It is far better to subdivide by twelfths, or eighths, or quarters, or halves than by tenths. It is also better to have a difference in the various steps, better and clearer to have 12 inches to a foot, and 3 feet to a yard, and so on. By this and by the nature of the units the Englishman has a clear realization of what his measures mean. A 16-inch shaft, a room 25 × 18 feet, a building site of so many yards,—they all stand out before him,—whereas after a whole century of the metric system the French will "think" in the old measures, and they mostly use them in conversation.

A French gentleman will invite you to share a pint, not a ½ litre, of wine; he will speak of walking a mile or two, not two or three kilometers; he will speak of being an inch, not three centimeters, taller than another; ask him the width of a room, and the reply will be in feet. Ask him a weight, and he will very likely give it in livres (pounds). The shops sell articles by the dozen, not by the ten, and they quote by the ½ kilo, or indeed, as I was amused to find, they sometimes say a kilo while measuring a half kilogramme!*

My much-esteemed friend, the late V. Daymard, of the Bureau Veritas, used to say that he had no conception of the diameter of a shaft except in inches, and yet he had had a high scientific and mathematical training.

The employment of decimals in long calculations is a necessity, but the greatest care must be taken of the decimal point. For clearness and accuracy a fraction is much superior. Once, when submitting a tender for a steamer to a French company, the head of the counting house made the following calculation:—It was to turn £45,600 into francs at the exchange of 25.25. He did it thus:—

$$4)45{,}600 \times \frac{100}{4} \text{ and add the } 0.25$$

$$\begin{array}{r} 11{,}400.00 \\ 1{,}140.00 \\ \hline 1{,}254.000 \end{array} \text{ francs.}$$

Now if he had multiplied by 25¼ (francs to the pound, he would have been less likely to fall into an error of 102,600 francs. He had moved the lower line of figures one place

*The French Mint has recently added to the coinage a nickel piece of the value of a quarter franc. The Parisians irreverently call it a pourboire!

only, instead of two places, to the right.

1,140,000
11,400.00

Francs 1,151,400, which is the correct figure.

The advocates of the metric system tell us that it will save so many years in the arithmetical education of children. This is an inversion of the truth. Under the metric system they really never completely learn arithmetic. The superiority of the English in mental calculation is generally recognized. And this advantage is, I think, partly due to their training. We all know how the clerks at a French ticket office are provided with a slate and chalk, but I was surprised to find lately at Wiesbaden that the officials at the telegraph offices could not calculate such a sum as 19 words at 20 pf. a word without having recourse to pencil and paper. I had only twice occasion to telegraph, and in each case they managed to make an error even with the help of paper!

A great deal has been said in Consular Reports and elsewhere about the disadvantage under which the English manufacturers labour of exporting cloth a yard wide to countries which have adopted the metric system. On my recent visit to Wiesbaden I met at table a large textile manufacturer, who exports to the East, and he told me that for all that market they make their cloth in yard widths.

It has lately been said that the British Empire counts for one-fourth of the inhabitants of the world, and British weights and measures must be familiar to at least another quarter. Why, then, do we seek to throw away this advantage?

I have not touched upon the question of a duodecimal notation. That would be a real advance,—and is it really so very difficult to conceive? Some people think it would be easier than the alteration of our weights and measures. At any rate, it would not to be a retrograde step.

I suppose that anything may pass the House of Commons, but were such a measure passed as that which would be involved by changing our weights and measures and making the metric system compulsory, I cannot believe it would have the slightest chance of confirmation if it were submitted to a referendum of the nation.

From F. H. Stillman, President of the Watson-Stillman Company, Hydraulic Machinery, Tools and Supplies, New York

IN his testimony before the House Coinage Committee, Mr. Stillman said, among other things:—"The enthusiasts favouring the introduction of the metric system all seem to forget that it is now a legal system, and one which could be used under any circumstances, should it be considered advisable. In the United States any concern or body attempting its use would soon find that their business would suffer very materially, as business is too well organized and is in too satisfactory a condition at present to permit freak legislation like this being passed without resenting it in some effective way. It must be remembered that legislation which does not have back of it those most interested in its use always remains a dead letter.

"This class of legislation is to-day one of the most dangerous results of too many sessions of our State and National legislatures. Our law volumes are full of measures which have been passed thoughtlessly, when introduced by some well-meaning, though not fully informed, member of our law-making bodies. The number of these ineffective and inoperative laws is one of the greatest

sources of discontent and frequently of blackmail, and it would seem advisible from some points of view if some power could be given to our Supreme Courts to strike from our statute books at frequent intervals this common class of freak legislation

"I am sure that all parties who have any business relations with standards of permanent measurement would believe, could such a method of getting rid of such bills be in existence, that this bill, should it be permitted to be placed upon the statute books, would be crossed from it by the courts at the first opportunity; but now, unfortunately, such bad legislation, once put upon the statute books, even though it would immediately go into a condition of 'innocuous desuetude,' would still be there, where some irresponsible party might invoke it for effect, as is now the case in several countries which have foolishly permitted the metric system to get a statute rating.

"The system of the inch, foot, and mile is the result of the necessities of more business men and business conditions through more continuous time than any other system, and it is in use freely by more people than the metric system has had assigned to it by legislation; and only a part of those nominally classed as using it, do so as a fact. If any class of men have strong ideas on this subject, it is that class who are in constant touch daily, hourly, and almost every second with standard linear measurements, such men as build railroads, ships and machinery, and every article which we use in our most common conveniences of life. They are all uncompromising opponents of this vicious scheme to force upon our workmen a system foreign to our thought and methods.

"Every organization, like the Railroad Master Car Builders and Railroad Master Mechanics, is unanimously against it, and their decision on any measure in convention is more powerful than any law for or against a standard, because the decision is reached only after experience has taught it to be right, and, once passed by a vote, it is almost as unchangeable as the historical laws of the Medes and Persians.

"Another organization, the Naval Architects and Marine Engineers, many of whose members are in the naval service, and more of them who have been, are almost unanimously against it as members and as a society, and it is the members of this body who would be most affected by it, and who would have to work under it very generally. A compulsory metric bill would impose still heavier disadvantages on the service of the United States Government than now exist, and they are now great enough to drive from the service or to a nervous death many a man whom our government cannot spare at this time.

"The great National Association of Manufacturers, whose membership consists of 3000 firms of the highest standing, operate factories in all varieties of manufacture, and whose heaviest assets and machinery are made to a scale which is in parts of inches and feet, are all against metric compulsion. Powerful organizations like the Machinery Manufacturers, the Machine Dealers and Supply Men, the Hardware Men's Association, the National Metal Trades Association, and many others have registered their opposition. This bill goes further than any of the previous ones in that it brings in the title deeds to all government lands. The government could not give a deed any more intelligible than a Spanish grant when disposing of any of the millions of acres of surveyed land not yet settled, which it has taken years to map out. What real estate owner wants to have the risk in a title of a computation by an average clerk in a register's office or in a lawyer's office when he has to record a deed to a piece of property which has passed through government hands?

"What fair-minded business man can respect the opinion of prominent advocates of this measure when they say that it is of no consequence if it does cost one firm a million dollars, as it will extend over several years? Is this not unconstitutional legislation, taking property without due process of law? The direct loss to the mechanical industries in new drawings, tools, jigs, patterns and records would undoubtedly cost over $500,000,000, and for what purpose? To meet the unsatisfied hope of a lot of theoretical instructors who never were connected with the affairs of life whose results were the advancement of the inhabitants of the country.

From Lincoln Chandler, General Manager of the Patent Shaft & Axletree Company, Ltd., Wednesbury, and Secretary of the Metropolitan Amalgamated Railway Carriage & Wagon Company

I AM opposed to the introduction of the metric system into this country primarily on account of the enormous cost which would be involved by the change, an amount altogether disproportionate to the advantages which could accrue.

Our workmen, having grown up under the present system, are all accustomed to working in inches, and would find the change as trying as we should find it expensive.

This, of course, if the object to be achieved were essential, is a poor argument; but is the adoption of the metric system essential or even advantageous?

By the use of the inch, decimally or duodecimally, and the pound, we get all we require for the practical purpose of our business, and as the inch is, I believe, used by the majority of the civilized population of the world, there seems to be no substantial reason in favour of a change, which would scrap all our gauges and land us, for a time at any rate, into the utmost confusion.

It is quite true that scientists, by their adoption of the metric unit, have admitted and advertised the superiority of the metric system over our present complicated and clumsy system of weights and measures, but it still has to be proved that the advantages of the former cannot otherwise be secured to us than by the entire overthrow of the latter.

Before coming to such a momentous decision as the compulsory enforcement of the metric system upon this country the government would be well advised to appoint a commission to thoroughly inquire into the possibilities of the improvement and simplification of our present system by the adoption of the inch unit.

From Coleman Sellers, Jr., President of William Sellers & Co., Incorporated, Philadelphia

AS representing the great firm of William Sellers & Co., Inc., the testimony of its president, Mr. Coleman Sellers, Jr., as given in the appended letter to the chairman of the House Coinage Committee, is of interest:—

"Our objections to the measure are founded, in general, on the following considerations:—

"1.—It is not demanded by the general public, by the manufacturing interests, upon whom its provisions would fall, nor are we aware that it is demanded by the heads of the Government Departments.

"2.—In other countries where similar legislation has been tried the result has been the introduction of confusion rather than simplicity. The old measures have been retained by the people to a great extent, and this is unavoidable.

"3.—In legalizing the metric units,

and in furnishing standards for comparison, our government has done its whole duty in the premises. If the French system is the best, it will, in time, supplant all others.

"4.—Our experience of over forty years' use of the French metric system in one of our departments has shown us no superiority, for shop purposes, of that system over the English, and we have not been encouraged to extend its use. Did it possess practical advantages, such as claimed, it would be to our interest to use it throughout our works.

"5.—The relations between units of different denominations, which is the merit of the metric system from a scientific point of view, is of no practical value to the manufacturer.

"6.—The decimal division is not, on the whole, as convenient for mental calculations, or the ordinary purposes of the shop and market, as the binary. Where it is more convenient, it can be, and is, applied to English standards, as by surveyors, and by machinists in making fine measurements, such as are expressible only in fractions of less than 1-64 inch.

"7.—There has been a steady and persistent effort in the manufacturing community for the development and adoption of standards in all lines of product. More has been accomplished in this country than in any other in this direction. We have, for example, standards in bolts and nuts, in pipes and fittings, in hose couplings, and innumerable other lines, so that it is possible to buy parts from different makers with the assurance that they will fit together properly. This is of incalculable advantage to the buyer and to the manufacturer, and has been the result of years of persistent effort. These standards cannot be abolished by any legislation whatever; the resulting chaos would be intolerable. The law proposed could result only in change of name by which the existing dimensions would be expressed in metric equivalents, resulting in awkward fractions; or new standards would have to be made, which would mean unnecessary duplication.

"It has been stated that the compulsory metric bill in question would not impose any hardship on the manufacturers of this country. Whether or not this view is sound, will depend upon the construction which is put upon the provisions of the act by the departments with which business is conducted. We can illustrate our meaning best by a concrete example. Suppose the naval gun shop should require to purchase a lathe for boring and turning what are now known as 12-inch guns, but which, we presume, would hereafter be designated as 305-millimeter guns. Such a lathe usually has a face-plate of about 85 inches diameter, and is long enough to take a gun of, say, 50 feet. The specification issued by the department might specify only these general dimensions in metric equivalents, thus, swing, 2350 millimetres; length to turn, 15 meters, 240 millimeters.

"If no other requirements were made, the proposition would present absolutely no difficulty to the manufacturer, who would simply offer his regular pattern of lathe of general dimensions nearest to those specified; but this is not strictly 'using the metric system,' and the conscientious officer might add to his specification a clause reading as follows:—'The metric system of measurements must be used throughout this machine. All dimensions must be in millimetres. All screw threads must have metric pitch, and all bolts must conform to the international system of screw threads on a metric basis and normal sizes of diameters, etc., adopted October 20, 1900.'

"Such a requirement would be fully warranted by the terms of the bill. What would be involved to the manufacturer attempting to meet this specification? He would have to make new drawings of the machine, change all the dimensions to millimeters, avoiding, as far as possible, fractions of millimetres. He would

have to arrange for a new series of bolt sizes, varying by increments of 1, 2, 3 or 4 millimeters, instead of by 1-16 inch, $\frac{1}{8}$ inch, and $\frac{1}{4}$ inch. He would have to adopt a series of bar steel sizes varying in a similar manner in place of those now used, varying by fractions of an inch. He would have to provide means of making and using these special bolts as cheaply as the bolts of the United States standard. This would involve a new set of drills, reamers, screw gauges, diameter gauges, threading tools, screw mandrels, boring cutters, etc., as well as metric lead screws or their equivalents. In addition to these changes, the proportions of the gear wheels would have to be modified according to the 'Module' system of metric pitches, which does not appear to be so convenient as the conventional 'per inch' system which is general in this country, and will require the manufacturer to procure a new equipment of milling cutters of the proper shapes and sizes.

"We do not think that the foregoing illustration is overstated, and admitting its possibility, we do not see how we can escape the conclusion that the manufacturer desiring to do business with the government might be put to considerable inconvenience and expense. It has been argued before your Committee that the expense of the special drawings, tools and fixtures could properly be charged to the purchaser, but even if the government were willing to pay the premium demanded, it certainly could not compensate the builder for the inconvenience of attempting to operate two standards in one shop. Nor does it seem right to tax the government (the people) for changes from which no practical benefit could result in increased efficiency of the machine."

THE COMMERCIAL MOTOR-VEHICLE IN GREAT BRITAIN

By Ernest F. Mills

IT is only the inherent advantages of mechanical traction over horse haulage that have enabled the motor goods-carrying vehicle to survive the failures which were characteristic of its early running. Although the same disagreeable episodes marked the early days of the motor-driven pleasure car, enthusiastic amateurs were not to be deterred from following a fascinating pastime by incidents which caused merely some slight inconvenience. On the other hand, every breakdown of a commercial vehicle means delay, deranged organization, and loss. There is, however, no room for doubt that the industrial motor-vehicle has passed out of the experimental stage, and with a careful study of the requirements of a case, and a choice of a suitable machine and driver, success is almost assured.

Ten years ago steam was the only motive power which could be applied efficaciously to motor-vehicle propulsion, and it was a natural consequence that but few light vans were attempted at that time, the trade being limited to the construction of heavy goods vehicles for the use of brewers, millers, iron founders, etc.

Vehicles intended for carrying loads as low as one ton were built in small numbers, but were not economical in use, the cost of running being almost as high as that of a vehicle several times the capacity. It was also found impossible by makers to construct such a vehicle at a much lower price than one carrying several times this weight. Such a van was also comparatively ungainly in appearance and inconvenient, the engine and boiler absorbing an undue proportion of the construction in relation to the loading platform.

A 5 TON PETROL LORRY BUILT BY MESSRS. JOHN I. THORNYCROFT & CO., LTD., CHISWICK, W.

The manufacturers at that period, therefore, were mostly concerned with ministering to the wants of those dealing with heavy freight, and the lighter delivery van was practically unknown until the petrol engine had developed sufficiently to enable it to be used for other purposes than propelling light cars. As soon as this degree of perfection

A MILK VAN BUILT BY MESSRS. MOSS & WOOD, BIRMINGHAM

had been reached, success was assured for the light commercial type of van, as the petrol motor possesses many advantages over its steam rival where lightness and cleanliness are desiderata. It is calculated that the petrol engine will give a result equal to that of the steam engine upon one-third of the weight of the fuel required by the latter while its mechanism is only one-sixth of the weight.

For small vehicles, also, and especially in the case of intermittent service, much lower running costs are incurred than with the "steamer." The latter usually requires two attendants, and the time required for getting up steam before use, and the necessity for drawing the fires afterwards make a great difference in the vehicle's service. With the petrol engine there need necessarily be no waste of fuel while the vehicle is standing, but with the steam engine consumption is usually taking place from the time the fire is lighted in the morning until it is raked out at night.

For the very heaviest work, however, the steam wagon still maintains the leading position, in the writer's opinion, both on the point of economy and durability, notwithstanding that at the moment the petrol motor is prime favourite with the majority of would-be employers of mechanical traction. Experience suggests that the petrol engine as at present constructed, is liable to suffer from the excessive vibration set up by running on steel tires, and, unfortunately, it is not yet commercially possible to carry very heavy loads on rubber tires.

However, it is unsafe to make any definite statement in these days of rapid progress, and it may be that sooner than is now expected the petrol vehicle will be as reliable as the "steamer" for heavy work. There is at present on the market a vehicle of this character built by Messrs. John I. Thornycroft & Co., Ltd., designed to deal with a load of five tons, and it is not to be assumed that a firm of such repute would sell vehicles of this type without first going carefully into its capabilities.

Early in the year it was announced that the sales of British-made motor-vehicles of all types in Great Britain exceeded the sale of all foreign imported cars, and although doubt has since been thrown on this statement, yet it is generally recognized that such cars can be built in

A THORNYCROFT COLONIAL TYPE STEAM WAGGON HAULING A GUN

Great Britain as cheap and reliable as by firms in Continental Europe.

There is at the present time increasing preference for British-made goods, and when it is considered that we have been importing foreign motor-vehicles to the value of some three and a half million pounds yearly, the prospect of business in this country seems extremely favourable.

It is difficult to discriminate between the number of commercial vehicles in use and those employed for pleasure purposes, as a tremendous number of ordinary cars are now in use by physicians, travellers, surveyors, and other business men; but it would not be far out to say that, including motor-omnibuses, nearly one-half of the motor-vehicles now running in Great Britain are employed in some commercial work. We are, however, concerned here chiefly with the freight-carrying vehicle.

Though we are, of course, practically shut out of foreign markets and can never hope to sell on a large scale in France or Germany, or in the United States, with their duties up to 50 per cent. ad valorem, yet it will show the enterprise of the British manufacturer when it is stated that several of the home firms are establishing factories in Continental countries, or arranging to have their vehicles built on a royalty basis by foreign houses. Messrs. Thornycroft & Co., for instance, have licensees constructing their steam and petrol lorries and cars in France, Italy, and Spain, among other countries.

Although debarred from sending their vehicles to such countries by hostile tariffs, there are still other countries and dependencies where the British manufacturer of motor-vehicles has demand for his goods, and where import duties are either non-existent or not more severe on the British maker than on anyone else; and it is gratifying to note that, so far as the industrial motor-vehicle is concerned, he has more than held his own in this respect.

India is proving a profitable market for such heavy automobiles, and the steam wagon has met with great favour there by cotton spinners and others dealing with heavy freights. The reason for this will be apparent when one considers that the usual method of transport is by bullock carts, that the load for a pair of magnificent animals is 30 cwt., and

that six miles constitute their day's work.

To arrive at a basis of comparison of the cost of various methods of haulage, the most satisfactory practice is to reduce all the expenses to the unit of the ton-mile. In getting out the cost of running of a motor wagon, the charges to be made against it are best divided up under standing charges, which include such items as depreciation, interest on capital, insurance, rent of wagon shed, etc.; and running charges, which include driver's and mate's wages, fuel, water, oil, repairs, etc. In their ultimate effect upon the cost per ton-mile, the headings differ in this respect,—that the standing charges remain practically the same irrespective of the weight of useful load carried and the distance traversed, whilst the running charges are nearly directly proportional to them. It follows, therefore, that since the standing charges are nominally the heavier, the economy will be determined chiefly by the ton-mileage which the machine is capable of returning, and secondly, by the ability of the machine itself to keep down to as low a cost as possible the items for running charges in relation to the ton-mileage made.

In order to obtain the greatest possible ton-mileage from a motor wagon, and consequently the lowest rate per ton-mile, it is obvious that the vehicle should maintain its highest average speed and be always loaded to its fullest capacity. This being the case, owners of motor-vehicles should, where horse haulage is still in use, give their motors the preference of the longest journeys, arrange for loading and unloading to be done with facility, and adjust matters so that, as far as possible, the wagon should never run light.

A THORNYCROFT PETROL VAN FOR VACUUM CLEANING SERVICE

A STEAM WAGON IN SOUTH AFRICAN SERVICE. ONE OF SEVEN SUPPLIED BY THE YORKSHIRE PATENT STEAM WAGON CO., LEEDS

It is difficult to give any definite information as to cost of running, as so much depends upon the conditions of service, type of vehicle employed, and other factors; but the following figures are supplied by an actual user of motor traction, and will, no doubt, appeal more strongly to those interested than would figures supplied by the manufacturers. The details were given by Messrs. Brain & Co., brewers, of Cardiff, and refer to the running of one of their Thornycroft four-ton steam wagons during 1905. A point to be noted, and which, no doubt, plays a great part in the very successful and economical working of this particular vehicle, is that the wagon is in service only five days a week, the sixth day,—Saturday,—being given up to overhauling and cleaning:—

CAPITAL OUTLAY

	£	s.	d.
One 4-ton steam wagon	650	0	0
One trailer	40	0	0

ANNUAL EXPENDITURE

Interest on capital (wagon) at 4%	26	0	0
Interest on capital (trailer) at 4%	1	12	0
Depreciation (wagon) at 15%	97	10	0
Depreciation (trailer) at 10%	4	0	0
Insurance	18	0	0
Repairs (wagon)	50	0	0
Repairs (trailer)	5	0	0
Coal, 7/- per day for 260 days	91	0	0
Oil and waste, 10/- per week	26	0	0
Water, 500 galls. per day at 8d. per 1000	4	10	0
Wages, driver at 40/- per week	104	0	0
Wages, 2 men (helpers) at 22/- per week each	114	8	0
Gates, 5/- per week	13	0	0
Total	554	0	0

ANNUAL PERFORMANCE

Working days per annum (5 days per week for 52 weeks)	260
Mileage per day	16.5
Load carried	14 tons.

The cost per ton-mile in pence is, therefore, $\frac{555 \times 240}{260 \times 16.5 \times 14} = 2.2d$

Although fallacious and disappointing in character, the heavy motor car order of 1904 is, no doubt, responsible for the increase in steam wagon construction, several new firms having entered this industry, with, of course, corresponding increase in the number of these vehicles, there being now about 1600 of this type in Great Britain alone in daily use. In nearly every instance where steam wagons have been adopted, the own-

A STEAM WAGON WITH LOCOMOTIVE BOILER BUILT BY MESSRS. JOHN I. THORNYCROFT & CO., LTD., CHISWICK, W

STEAM WAGON WITH INTERCHANGEABLE WATERING AND TIPPING BODIES BUILT BY THE YORKSHIRE PATENT STEAM WAGON CO , LEEDS

ers have met with complete success, and the few cases of failure recorded have been invariably due to the wagon not having received proper attention.

It is impossible to enumerate all the uses to which steam vehicles have been successfully applied, but all firms dealing with heavy loads have found them economical and time-saving machines. Brewers, millers, contractors, railway companies, furniture movers, coal merchants, mine operators, cotton and sawmill owners, iron founders, ammunition manufacturers, paper makers, calico printers, provision merchants, municipal authorities, and brick makers are a few of the principal users.

The figures adjoining compare the running costs of petrol delivery vans, carrying light loads, and horse-drawn vehicles, and are compiled from data obtained from Lacre vans whilst in actual service carrying out deliveries for Messrs. Shoolbred, Maple, Hedges & Butler, and other London firms.

It will, of course, be recognized that the lighter the loads dealt with by motor traction, the greater the cost per net ton-mile, but this is applicable also to other modes of transport, in a greater or less degree.

The petrol van is at present in use mostly by firms trading in light goods, and where a high average speed is an advantage. A vehicle of this type, carrying a load of one to two tons, and running on rubber tires, is quite capable of a 60-mile daily run, if but few stops are necessary, while with the heavy steam wagon from 30 to 40 miles are about the most that can be expected.

Whatever the type of vehicle employed, whether it be a slow-running, heavy steam wagon, or a swift-running, light petrol delivery van, it is not too much to say, if such are properly handled, that the cost comes out at about half that by horse haulage. Many up-to-date firms have testified to this fact. In the case of a steam wagon we have seen that the cost per net-ton-mile can be brought

ANNUAL COST OF RUNNING 1-TON LACRE VAN 60 MILES A DAY FOR 300 DAYS

CAPITAL OUTLAY

	£	s.	d.
One 1-ton petrol van	415	0	0
Sundries	5	0	0
Total	420	0	0

ANNUAL EXPENDITURE

	£	s.	d.
Interest on capital at 5%	21	0	0
Depreciation at 20%	84	0	0
Insurance	10	0	0
Storage at 5/- per week	13	0	0
Annual repaint as agreement with Lacre Co.	10	0	0
Cleaning at 10/- per week	26	0	0
Driver at 30/- per week	78	0	0
Petrol, 15 miles to the gallon, at 7d. per gallon for 18,000 miles	35	0	0
Oils—gear, lubricating and lamp	5	0	0
Tyres, as per agreement with mfr	75	0	0
Renewals (tyres not included)	20	0	0
Total	377	0	0

ANNUAL COST OF RUNNING 2 TWO-HORSE VANS 30 MILES A DAY FOR 300 DAYS

CAPITAL OUTLAY

	£	s.	d.
Two vans at £45 each	90	0	0
8 horses at £40 each	320	0	0
2 sets of harness at £10	20	0	0
Sundries	5	0	0
Total	435	0	9

ANNUAL EXPENDITURES

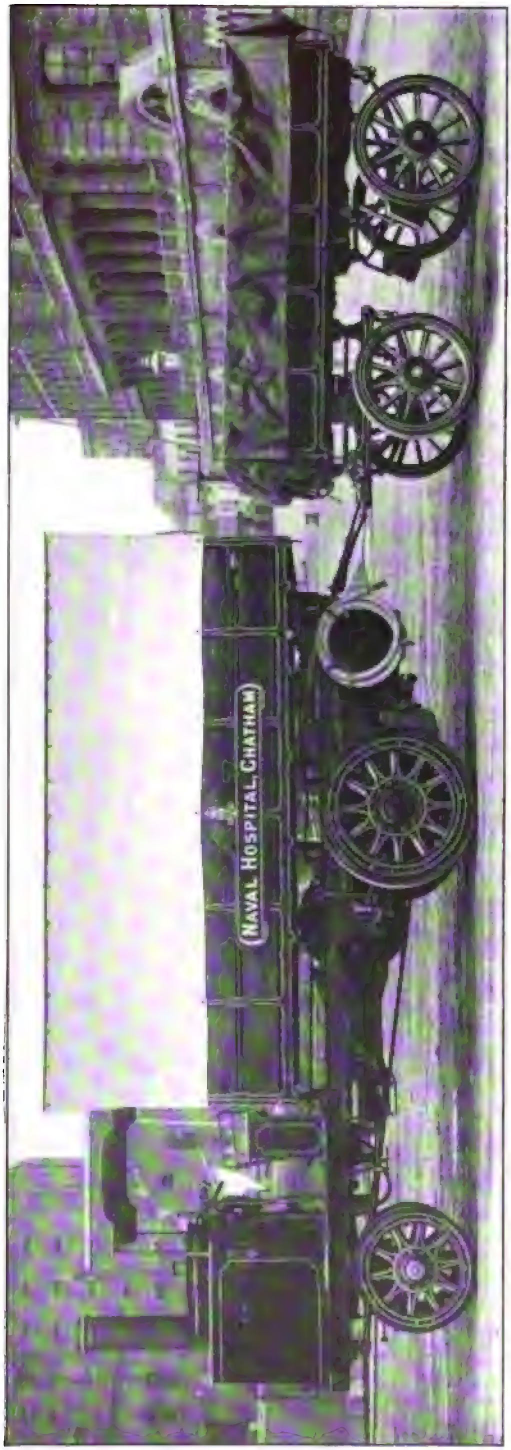
	£	s.	d.
Interest on capital at 5%	21	15	0
Drivers, 2 at 28/- per week	145	12	9
Forage, 8 horses at 10/6 per week	218	8	0
Stabling, 2 vans, 8 horses, 40/- per week	104	0	0
Insurance	20	0	0
Shoeing and vet., 8 horses at £8 per annum	64	0	0
Renewals, 2 vans at £5 per annum	10	0	0
Depreciation (horses) at 20%	64	0	0
Depreciation (vans, etc.), 15% on £115	17	5	0
Annual repaint, 2 vans at £10	20	0	0
Cleaning 2 vans and looking after 8 horses, 2 ostlers wages at 25/- per week, each	130	0	0
Total	815	0	0

The two cases compare exactly as to weight carried and daily mileage.

Cost of work performed by horse-drawn vans	£815
Cost of work performed by petrol van	377
Net saving per annum	£438

down as low as 2.2 pence, whereas with horse draught, under the most favourable circumstances, the figure seldom falls below 4 pence.

The unparalleled success of the motor-omnibus is, no doubt, responsible, to a great extent, for the activity which at present prevails in the commercial vehicle industry, and in addition to the increasing number of private firms who are adopting motor traction in lieu of horse haulage, the past few months have wit-



A STEAM VEHICLE IN USE BY THE CHATHAM NAVAL HOSPITAL BUILT BY MESSRS. SIDNEY STRAKER & SQUIRE, LTD., LONDON

nessed the advent of many large motor carrying companies who will undertake to deliver a firm's produce by motor-vehicle, thus relieving such establishments of the onus of maintaining such a necessarily expensive vehicle themselves. In many rural districts the agricultural communities are looking to the motor-wagon as a panacea for their troubles, and there is no doubt, where railway facilities are few or rates high, that the motor-wagon will enable them to get their produce to market with the least delay and at a low cost.

One of many such projects under consideration is that in Essex. In this case arrangements are being made to supply London with agricultural produce by means of an organization which is to collect the various goods at centres situated in Chelmsford, Braintree, Dunmow, Epping, Ongar, Witham, and many other towns. These collecting centres are to be furnished with slaughter-houses, chilling rooms, creameries, and grading and selecting departments to deal with the produce brought to them from the surrounding country by motor or otherwise, and thence it will be forwarded to London by motor-wagon. A somewhat similar system of collection is meeting with success in Berkshire.

Although the motor lorry cannot compete with the railway under certain conditions, the road vehicle holds a distinct advantage when the journey is short and when the goods in transit require careful handling. In such cases the cost for ter-

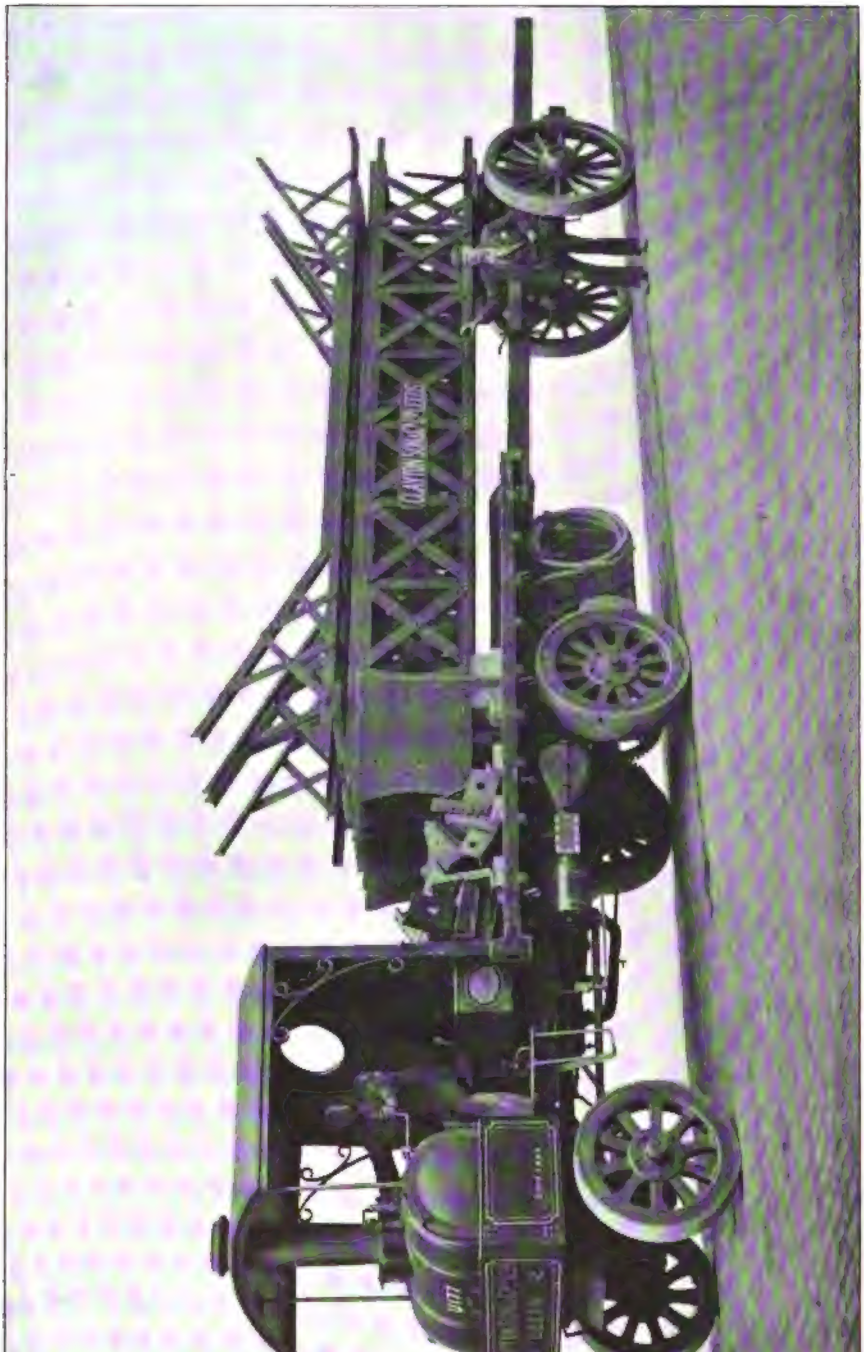
minal handling and terminal accommodation more than counterbalances any economies which are effected in actual rail haulage. Where the distance is short, and where the article carried is such that a considerable amount of handling is required, cartage throughout, which saves two handlings, or more, must always remain cheaper.

Another promising outlook for the industry is the rumour that the colliery owners are contemplating a system of direct deliveries of coal from pit mouth to consumer by steam lorry. It is remarkable that such a system has not been more in vogue where coal fields are within easy reach of industrial centres, as, for example, in Lancashire. The mode of procedure at present is for the colliery owners to load trucks on the railway, have them hauled from 20 to 25 miles by rail, unloaded to carts, and eventually delivered to the consumer, sometimes three or four days being occupied in this manner, when, by employing steam wagons, as many hours would probably be occupied and the cost reduced to a minimum.

Nothing could better demonstrate the rapid advance in public favour of the commercial motor during the past twelve months than the decision of the Society of Motor Manufacturers and Traders to hold henceforth a separate exhibition of such vehicles. A contract has been entered into with the proprietors of the Olympia, in London, for an exhibition of this character to be held about April of next year and for the following years up to 1913, in addition to the private car exhibition.

The present solution of the traffic problem in London and provincial towns no doubt lies greatly in the employment of motor goods-vehicles in conjunction with motor-omnibuses, and it has been predicted that in London in ten years' time not a horse will be employed for traction work. Whether this is too sanguine a view or not cannot be determined, but that the supply of horses will

AN 8 H.-P. DELIVERY VAN BUILT BY THE WOLSELEY TOOL & MOTOR CAR CO LTD., BIRMINGHAM



A STEAM WAGON AND TRAILER FOR CARRYING GIRDERS, RAILS, ETC., IN LENGTHS UP TO 50 FEET. BUILT BY THE YORKSHIRE PATENT STEAM WAGON CO., LEEDS

A PETROL LORRY BUILT BY THE LANCASHIRE STEAM MOTOR CO., LTD., LEYLAND

soon cease to be available owing to the increase of self-propelled vehicles has occurred to the War Office authorities, is evident by their letter recently addressed to the Motor Van & Wagon Users' Association desiring to know whether they would support a scheme for registering heavy motor-cars for the service of the country in time of war in the same manner in which horses have hitherto been subsidized.

SOME ENGINEERING PARADOXES

By A. H. Gibson, B. Sc.

PROBABLY most engineers have heard of the old naval officer who was explaining to a lady what were the duties of the various ranks on board ship. "And what are the engineers?" she asked at length. "Oh, an engineer is a fellow who turns a handle, you know, and then the engine goes round."

Unfortunately, however, for the peace of mind of many a man, the engine, or its equivalent, does not always go round when the handle is turned, and a more appropriate definition of an engineer would appear to be, "a fellow who knows what to do if the engine doesn't go round."

Almost every engineer of experience has come across such cases, in which the engine, or its equivalent, did not budge, be the handle rotated ever so vigorously; or, to put it more generally, in which the anticipated effect failed to follow any given cause, and in which, at first sight, all cherished theories seemed to be suddenly at fault, and the fundamental laws governing the action under consideration to have become inoperative. Of course, this can be due only to the fact that some of the circumstances governing the action are either imperfectly known, or misunderstood. The action must necessarily be governed by the laws of nature,—and where all these circumstances are fully known the effect is seen to be no longer paradoxical.

It is proposed here to consider a few of such apparent paradoxes in different branches of engineering, and to give or suggest as far as possible some explanation in each case.

For example, it appears paradoxical, to still consider the steam engine, that the most efficient engine and boiler plant is not necessarily the most economical, that the highest degree of vacuum should not necessarily be advantageous, that by cutting off steam earlier in the low-pressure cylinder of a compound engine the mean effective pressure and work done in that cylinder is increased and not diminished. On examination, however, these paradoxes disappear.

By the most efficient steam plant, we mean that which develops the most useful work per pound of fuel burnt in the furnace, while by the most economical plant we mean that which develops most useful work for every unit of cost to the user. A steam plant may be made more efficient in many ways,—by superheating the steam, by using higher boiler pressures, by using a higher vacuum in the condenser, by jacketing the cylinders, by reheating steam between cylinders, by tripling or quadrupling, to quote the chief methods used in common practice.

But with superheating, in addition to the increased capital cost and that due to depreciation of the plant, we need extra labour if a separately fired superheater is used, as well as an increased supply of more expensive lubricating oil, this being par-

ticularly the case with high degrees of superheat. Also it is actually a fact in some special cases that, because of difficulties of lubrication, the brake-horse-power of an engine has been reduced, though the indicated horse-power has been increased, by superheating.

The use of higher working pressures, again, demands a more expensive plant, though within limits, it is perfectly demonstrated in practice that an increase in boiler pressure does lead to actual increased economy of working.

The use of a higher vacuum means greater expense in many ways. To begin with, a larger and more expensive condensing plant is required, necessitating a larger water supply, and a greater power to drive the air pump. With this is coupled greater difficulty in keeping the condenser tight. So much is this the case that, although in a steam turbine plant a good vacuum is more essential to efficient working than with an ordinary reciprocating engine, even there the high vacuum demanded by the turbine builder does not tend to economy of working, as opposed to efficiency of working, as the builders themselves would in all probability agree.

The other methods of increasing efficiency,—jacketing, reheating, and tripling or quadrupling,—although with properly designed plants working under suitable conditions, invariably giving increased efficiencies, do not necessarily give increased economy because of the more expensive engine demanded in each case.

Taking the other paradox, we know that with given cylinder ratios, and a given cut-off in the high-pressure cylinder, the total ratio of expansion in any engine is fixed, regardless of the point of cut-off in the low-pressure cylinder, and the work got out of the steam depends only to a minor degree on this cut-off. Since the weight of steam per stroke taken by the low-pressure cylinder is constant, and since, with an earlier cut-off, the volume it occupies in the cylinder at cut-off is less, it follows that with an earlier cut-off its pressure must be greater, and, therefore, that the back pressure in the high-pressure cylinder will be greater than with a late cut-off in the low-pressure cylinder. This means that the mean effective pressure, and, therefore, the work done in the high-pressure cylinder will be less with an early cut-off in the low-pressure cylinder, and consequently that the work done in the low-pressure cylinder will be greater as the cut-off is made earlier.

Next, consider the method of heating boiler feed-water with live steam. The steam is taken either directly from the main or from an auxiliary boiler, or from the receivers of a steam engine, and is used to heat up cold feed-water to almost boiler temperature before being pumped into the boiler.

This was first proposed in order to lessen the stresses in the boiler caused by alternate contraction and expansion when cold feed is pumped directly into it, and it probably caused the proposer as much surprise as anyone when, in addition, it was found that the coal consumption of the steam plant was considerably reduced. At first sight, it appears most paradoxical that this double process of first producing the steam and then condensing it to heat feed-water which again enters the boiler, should be productive of economy, since less heat must enter the boiler than left it, on account of radiation losses which are unavoidable.

Thermodynamically, too, this method of feed heating is as bad as the heating by direct pumping of cold feed into the boiler, except in the case of the multiple-stage feed heater, so that we must inquire into the physical cause which may effect an economy sufficiently great to overbalance this thermodynamic loss.

It is well known that the flow of heat through the plates of a boiler

will vary as the difference of temperature between the two sides of the plate, and that these temperatures will be respectively lower than that of the furnace gases and higher than that of the water with which the plate is in contact. The heating surface, too, may perform either of two functions,—it may simply have the duty of heating water which is below the temperature at which steam is being produced in the boiler up to that temperature, or of simply evaporating water already at steam temperature into steam. With cold feed, its function will consist of a combination of these; with hot feed, only of the second of these.

In the second of these cases, any transfer of heat is quite independent of any conduction through the water, and heat is extracted with greater rapidity from the hot plate. In other words, with water at a mean temperature of, say, 250 degrees, not forming steam, in contact with a hot plate, not so much heat will be abstracted from the plate as if the water were boiling and forming steam at the same temperature. This is due to the fact that when the water is boiling freely, the temperature of the water side of the plate is very slightly above that of the water, while with water not in a state of ebullition the plate may attain temperature largely in excess of the water with which it is in contact. This produces a more gradual temperature gradient through the plate, or with the same temperature gradient a higher temperature on the fire side of the plate, with a consequent slower rate of exchange of heat from hot gases to furnace and a resultant rejection of a greater proportion of heat to the chimney.

A contributory cause is introduced when cold feed is injected near the surface of the water in a boiler, as is usually the case. The effect of the descending stream of cold water is to put a stop to circulation, if it should meet a rising stream of mixed heated water and steam bubbles, and any cause tending to stop natural effective circulation, and a consequent continuous replacement of heated water and steam bubbles by fresh water, producing, as it must do, a higher plate temperature, directly tends to inefficiency of the heating surface.

Closely allied to this subject of live steam feed heating comes that of thermal storage for steam boilers. The arrangement consists simply in the addition to a boiler, or battery of boilers, of a large storage tank of considerable capacity, suitable connections being made to enable cold feed to be pumped into this tank, to enable steam at boiler pressure to be constantly in communication with the surface of this water, and to enable the feed-water heated by this steam to enter the boilers as required.

At first sight, it does not seem as if this should have any great effect on the economy and steam capacity of the boiler plant, certainly not such a great effect as is vouched for by several independent authorities in practice, where, in favourable cases, the evaporation per pound of coal has not only been increased by amounts as great as 19 per cent., but the evaporative power of the plant also has been almost doubled for short periods of peak load.

At light loads the cold feed is pumped into the storage tank at a rate much higher than that at which steam is being delivered to the engines. As much as is required to keep the boiler level constant is drawn from the tank, and the excess accumulates until the tank is filled.

The pumps are then regulated so as to keep the tank full until the heavy load comes on, when they are stopped, and all boiler feed is drawn from the tank at approximately boiler temperature. At one electric light and power station, Babcock & Wilcox boilers having a normal output of 12,000 pounds of steam per hour, with feed at 150 degrees F., are said to give, when using the sys-

tems of thermal storage, an evaporation of 30,000 pounds per hour, the working pressure being 210 pounds.

With feed at 150 degrees pumped directly into the boiler, 1083 B. T. U. would have to be supplied per pound of steam formed, while with water at boiler temperature supplied from the thermal storage tank, only 836 B. T. U. additional would be required per pound of steam. If, then, this were the only cause tending to increase the rating of the boiler, this should be increased in the ratio $\frac{1083}{836} = 1.3$, and this is not nearly sufficient to account for the actually greatly increased rating.

Suppose, moreover, the pressure were allowed to fall during the peak load to 190 pounds. The temperature of the water in the tank and boiler would be reduced 8 degrees F., and assuming a total of 50,000 pounds of water in boilers and tank, this would give an additional available amount of heat of 480,000 B. T. U. With a peak load extending over four hours, we would have 120,000 B. T. U. thus available per hour, which would cause the evaporation of $\frac{120{,}000}{839} = 150$ pounds, or only about 6 per cent. of the whole evaporation.

Evidently, then, the large increase in evaporative power is not to be accounted for wholly in this way, and must be due mainly, as before, to increased efficiency of the heating surface of the boilers, caused by an increased mean temperature in the boilers and by improved circulation. Part of the increased saving is undoubtedly also due to the fact that all blow-off at safety valves with the peak load is prevented, and that easier firing at the peak is permissible, with consequently less heat given to boiler brickwork and thus lost by radiation. Also, priming is prevented by the increased uniformity of working of the boiler; particularly is this the case with water-tube boilers.

When thermal storage is used,—not to help the plant over the peak of the load, but in normal working,—the heat units to be given to the boiler per pound of feed will be unaltered by the presence of the storage tank, which then simply becomes a live steam feed heater.

A paradox first pointed out by Professor Goodman is connected with the governing of Pelton wheels or impulse turbines. With these the water is directed on to the wheel vanes or buckets by nozzles, and governing is effected by throttling the supply of water to the wheel, by altering the effective area through the nozzle.

Consider a case where a Pelton wheel takes water by a pipe line of considerable length from a supply reservoir at some distance above on the hillside. Naturally, one would expect that on throttling at the nozzles, the speed of the wheel and the work given out would be reduced, and that on opening out the nozzles the speed would increase. In some particular cases, however, the reverse is the case, and on throttling the supply the speed increases, while a greater supply of water causes a diminished speed.

This can easily be accounted for, if we note that the total head of water above the nozzle is used up in giving kinetic energy to the water at the nozzle and in overcoming frictional and other resistances due to bends and variations in sections of the supply pipe. As the nozzle area is increased from zero, the velocity of flow through the main increases, while the velocity through the nozzle decreases, and also the various frictional losses, which vary as the square of the velocity in the main increases. It follows that although a greater quantity of water is being delivered from the nozzle per minute as the nozzle area is increased, yet the velocity of efflux of this is being diminished, due to the greater

nozzle area and to greater frictional losses, until a point is reached at which any further opening of the nozzle causes a decreased supply of kinetic energy in the issuing water and a consequent reduction in the speed of the turbine. The areas of main and nozzles should be so arranged that the kinetic energy of the jet always increases with the nozzle area.

Again, it appears paradoxical at first sight, that in a single or a double-acting reciprocating plunger pump, it should be possible to get a volume of water pumped largely in excess of the volume of the plunger displacement. It would appear that, on account of "slip," the delivery volume would be less than this rather than greater, though in practice the opposite is often the case. This can be explained as follows:—

During the latter half of any suction stroke, the plunger is being retarded. The column of water in the suction pipe is being retarded at the same, or a greater rate, according as the diameter of the suction pipe is the same as, or less than, that of the plunger, the force necessary to cause this retardation being supplied by pressure in the pump cylinder. If the retardation is sufficiently great, or if the mass of the column of suction water is sufficiently large, this pressure necessary to cause retardation will become greater than the delivery pressure, and for the rest of the suction stroke the pump will deliver through the delivery valves.

Some apparently paradoxical results are obtained when we study the flow of gases,—either when passing through a jet or small orifice, or when unconfined laterally. It would appear, at first sight, that if an orifice were made in the division plate between two vessels containing a gas at different pressures, the weight of gas passing the orifice in a given time would vary as the pressure difference, or at least would be greater as this pressure difference increased. For small differences in pressure this is so, but when the lower pressure falls to a certain proportion of the higher,—0.527 in the case of air,—we get a maximum weight of gas discharge through the orifice. Any further reduction of the pressure on the low-pressure side is unaccompanied by an increase in the weight of gas passing the orifice. The explanation of this paradox is well known, and depends on the fact that as the pressure falls, the velocity of the gas through the orifice increases, while at the same time the volume of unit mass increases. When the pressure drop is small, the rate of increase of velocity is greater than the rate of increase of volume, and so, as the pressure drop increases, the weight of gas passing the orifice increases. This goes on until the pressure on the low-pressure side is 0.527 of that on the high-pressure side, when the rate of increase in velocity is exactly equal to that of increase of volume. After this, the volume increases at a greater rate than the velocity, and any further reduction in pressure on the low-pressure side does not cause a further fall in pressure exactly at the exit side of the orifice, the excess between this and the near lower receeiver pressure being used up in causing lateral expansion of, and in giving kinetic energy to, the gas.

When the action of air in motion, when unconfined laterally, is considered, as exemplified by the effect of wind pressures on roofs and on exposed buildings generally, some very paradoxical results are obtained. One of these is noticed in the effect of wind pressure on an oblique plane. Here the resultant normal pressure of the air is found to be in some instances much greater than on a similar plane of similar area when normal to the air current, the greatest normal pressure occurring when the inclination of the plane is about 45 degrees to the direction of the air current.

This is due to the fact that on the leeward side of a plane, or curved

surface exposed to a current of air, we always get a normal pressure less than that of the undisturbed atmosphere, and that as the inclination of the surface to the direction of the air current diminishes this negative pressure on the leeward side increases at a greater rate than the positive pressure on the windward side diminishes. The sum of the two, giving the resultant normal pressure on the surface, therefore increases until the angle of inclination is about 45 degrees. This negative pressure is due to the formation of eddies behind the plate, vortex rings being formed behind the edge of the plate, consisting of air partly from the front of the plate and partly drawn from behind. These eddies grow until the whole space behind the plate is filled, when they break away and drift away, other eddies then being formed. This formation can be very easily noted if smoke be introduced into the current of air.

Much the same action can be noted in the case of a flexible rod dipping into a uniform stream of water. Here, as the width of the part under water is increased, we get a width at which the bar is set vibrating, and maintained in a state of vibration. On introducing aniline dye into the stream, we can note that the formation of eddies behind the rod occupies a definite time, depending on its width, and that vibration is set up in the rod when the time of formation of an eddy synchronizes, or nearly so, with the natural time of vibration of the rod.

This negative pressure on the leeward side of a surface accounts for the paradoxical effects sometimes noticed during heavy gales, when the whole of the back of a building has been blown out, or a roof lifted off, instead of having been blown in. The upward current of air produced by the vertical windward wall of a building will produce eddies on the windward slope of the roof, which, with a roof of small inclination,—up to 35 degrees,—are sufficient to cause a negative pressure even on this windward slope.

In the design of prime movers, whether steam, gas, or petrol engines, one very important point to keep in mind is the provision for allowing the motive fluid to escape freely from the cylinders after doing its work, either into the atmosphere or condenser. The exhaust pipe for conveying the fluid should be short, so as to avoid friction losses as far as possible. This appears to be what one would naturally expect, and it therefore comes as rather a shock to be told that the addition of a silencer to the end of the exhaust pipe of a petrol motor, in some cases, instead of increasing the back pressure, actually diminishes this, and enables the motor to develop a greater horsepower. The same thing happens in some cases if the exhaust pipe is simply lengthened.

To attempt to account for this paradoxical effect, it should be noted what happens when communication is made between a cylinder containing steam or hot gas under pressure and the atmosphere. The fluid rushes into the atmosphere, displacing a volume of the atmosphere equal to its own volume at atmospheric pressure, and in doing so performs work.

The sole object of a condenser in a steam engine, by the way, is to prevent the escaping steam from having to do work in displacing the atmosphere, and hence to leave more of its energy available for use on the engine piston. If in any way, then, we can reduce the work to be done in displacement of the atmosphere, we get a clear saving in energy which may be turned to useful account.

But the gases from a petrol engine are rejected at a temperature of, say, 800 degrees F.=1260 degrees absolute, and, if turned directly into the atmosphere, will do a certain amount of work by displacement. Suppose these gases are first passed through a cooler of some description,—such as might well be sup-

plied by a cool exhaust pipe, or silencer,—so that their temperature is reduced to 630 degrees absolute=170 degrees F. before being turned into atmosphere. Their volume will be reduced to one-half that on leaving the cylinder,—neglecting the difference in pressure,—and consequently the volume of air displaced and the work done in this displacement will be one-half that done in previous cases.

The effect of thus increasing the length of the exhaust pipe, or of the silencer, will be to increase the frictional losses, so that there will be some most suitable length of pipe with which the energy loss due to friction due to further increase in length is balanced by the increase in energy available for work on the piston, due to the cooling effect.

It would appear in connection with this that a water-cooled exhaust pipe might be profitably employed with high-power petrol motors, along with water-cooled cylinders.

Several minor causes may also contribute to produce this paradoxical effect. It seems possible that the sudden opening to exhaust at regular intervals will set up a system of waves of pressure in the exhaust pipe, and the length of pipe and period of oscillation might be so arranged that a node of the wave is stationed at the inner end of the pipe where the exhaust valve opens. The effect of this will be to make the pressure at the other side of the exhaust valve less than that of the atmosphere, and to cause a reduced back pressure in the cylinder.

The column of gas in the exhaust pipe, too, when once set in motion, requires an applied force to retard it, and this force would be supplied by a difference between the pressure of the atmosphere and that at the exhaust valve. There is still another circumstance which, in special cases, may affect the back pressure. A mass of gas, projected suddenly from a circular orifice, such as the end of an exhaust pipe, may leave the pipe in either of two ways,—either in the form of a vortex ring, or as a disturbed eddying mass. In each case the work done by the gas, simply due to the displacement of the air, is the same; but in the case of the vortex ring, this work is done with the minimum possible disturbance of the atmosphere, and hence with the minimum loss of energy due to eddy formation in the atmosphere.

It would appear that whether a vortex ring is produced or not, depends largely on the velocity with which the gas leaves the pipe, and that, should the velocity exceed a certain value, the issuing motion will be turbulent. Cooling the gas, then, before its exit, and hence reducing its volume and velocity, will possibly change the motion from ordinary turbulent to ordered turbulence,—the vortex ring,—and thereby reduce the external work to be done by the gas.

These, then, are characteristics of the paradoxes which may be found in almost endless profusion by any careful observer in every-day practice. So many and varied are the unknown factors which vitally influence the behaviour of any motive fluid, such as steam or petrol vapour, whether during its production or its application, that perhaps in this field, more than in any other, the paradox is specially rampant, and it behooves one to be wary in prognosticating the effect of any hitherto untried change.

Certainly nothing is more productive of good than the study of such paradoxes, and the attempt to determine the hidden factor, and probably one of the chief charms of the profession of engineering lies in the very fact that so much scope is still left for the personal element in the solution of such problems.

DIRECT CASTINGS FROM THE BLAST FURNACE

By W. H. Butlin, B. A., Cab. de Isabel la Catolica

A PIG IRON SAMPLE TURNED AND DRILLED

AS the result of experiments conducted by the writer at the Irthlingborough Iron Works, Wellingborough, Northamptonshire, England, in the manufacture of direct castings from the blast furnace, the opinion is ventured that this method has not received the attention which it deserves. Results more recently obtained, both in regard to the quality and uniformity of the castings produced, bear this out.

It is not claimed, of course, that direst casting is a new departure in metallurgy, but owing partly to the demand for complicated castings, in which exact demands involve remelting in the cupola, and in part to lack of proper mixtures and want of uniformity in the resulting metal, the practice has not been followed to any great extent except for rough castings for works' purposes or for the cheaper shapes of cast-iron goods not called upon to reach a standard of any specified excellence.

To produce castings direct from the blast furnace without the intervention of the cupola naturally presupposes a sound knowledge of the composition and the mixture of iron ores employed and the same in regard to the flux, fuels, and resulting pig metals, and it was just this kind of knowledge, acquired by lengthy experience in the smelting of Northamptonshire ores, that suggested to the writer the possibility of greatly improving the quality of this class of castings by aid of scientific mixture.

Acting on this supposition, the writer, taking advantage of the varying chemical composition of the Northamptonshire iron ores, adopted the practice of sorting and selecting them according to their chemical composition, and then united them as a mixture for the blast furnace in proportions which their chemical composition and experience dictated. This is, in effect, mixing ores of different composition in the blast furnace instead of mixing different kinds of pig in the cupola to obtain the required result. It will be seen at once that this method is productive of two things,—greater accuracy as well as uniformity in the castings turned out,

A tabulated statement of some Northamptonshire ores is here introduced in order to illustrate several distinctive varieties occurring in the district, in which silica, lime and alumina are more or less the preponderating characteristics, and from which the required mixtures are chemically formed. The ore may be described chemically as a brown hematite, in fact, a hydrated sesqui oxide of iron, containing about 6 to 7 per cent. of water of combination, in addition to the hygroscopic moist-

SPECIAL TUNNEL SEGMENTS CAST DIRECT FROM THE BLAST FURNACE

ure found in it. The yield of the raw ore averages in the bulk 34 to 37 per cent., but a certain percentage of calcined ore is used to augment the metallic yield.

ANALYSIS OF NORTHAMPTONSHIRE IRON ORES

	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Iron	34.78	40.720	31.92	36.26	34.26	33.16	41.10	53.20
Alumina	4.76	5.786	5.09	7.17	7.51	7.36	4.00	2.30
Lime	1.09	1.850	6.26	3.27	1.53	1.82	3.15	.41
Phosphoric acid	1.71	1.385	1.60	.876	1.34	1.43	1.86	1.03
Silica	9.20	8.010	8.13	7.98	15.00	13.23	13.65	5.33
Moisture	22.00	12.00	18.70	16.00	11.50	17.30	15.50	14.20

In connection with the iron ore supply, when the phosphorus, although to a certain extent giving a clearly defined casting, seemed somewhat too high, carbonates, found in the district, were in special cases readily utilized to reduce the phosphorus to less than 0.50 per cent.

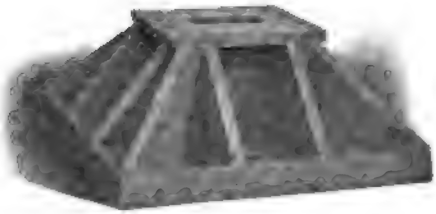
Fuels next demand attention, not only from the standpoint of their calorific value, but also, and particularly, their freedom from sulphur, and the writer is of the opinion that in direct castings it is possible to get the sulphur lower than in castings produced by the cupola in the second melting on account of the second use of fuel in melting the pig and scrap; indeed, in the direct castings, made at the works referred to above, the sulphur has been shown to be as low as 0.04 per cent. and even lower. It is necessary to point out in this connection that care should be taken that the ash of the fuel is low in order to get the metal hot and fluid, as high ash acts detrimentally in this direction.

Careful attention should also be given to the flux employed and to the selection of the limestone in order to insure as far as possible that it will be porous and that it will

flux readily and facilitate the admittance of graphitic carbon into the iron. Its chemical relation in regard to the ore is also of considerable importance; and besides studying the chemical relations of the iron ore, the limestone, and the fuel combined, our aim should be chemical combinations of silicates of lime and alumina and possibly other oxides in less proportions, to form combinations as slags fusible at low temperatures in the blast furnace, one of our aims being to get strong reducing gases in the zone of reduction of the blast furnace.

In a works where the manufacture of direct castings is carried on, the general equipment of the foundry should be simple though efficient, and in order to effect economy in labour the operations from start to finish should be arranged in consecutive order as is in fact the general practice in all modern works. In the writer's works, unless the stipulations or requisitions are for cupola castings, the foundry supply is provided by a pair of blast furnaces whose combined capacity is about 700 tons weekly. The casting channels for running the metal have been extended beyond the pig beds of the furnaces to the side adjoining a sunk pit containing the receiving ladles which vary in capacity from 3½ to 5 tons. These are taken by a locomo-

A DIRECT-CAST PISTON RING



A COLUMN BASE

tive crane running on rails, to the foundry which is a rectangular building, open at the ends, with a railway running down the middle, separating the floor space for the moulds. The ladles are removed and manipulated by means of differential pulley blocks mounted on bogies running on overhead rails. Tunnel segments and other special castings are moulded in the foundry with ordinary sand. The castings turned out by this method are frequently required in practice to be submitted to a specified drop test of 28 cwts on a bar 3 feet 6 inches long by 2 inches by 1 inch, set 3 feet between centers.

The construction of the various "tube" railways in London has created a considerable demand for these direct castings, and the experience obtained in carrying out a number of large contracts for tunnel segments for these railways has afforded ample opportunity of demonstrating beyond doubt the excellence of the results obtained on scientific lines, and consistent uniformity has been maintained, whilst the castings themselves have been sound and solid with practically entire freedom from blow-holes, and, so far as experience dictates, would compare favourably with cupola castings generally. In confirmation of this it is on record that 5000 tons of segments were turned out at the rate of 80 tons weekly, about 80 per cent. of which were from direct metal and machined to requirements. The segments, some of which are illustrated on page 240, weighed about five cwts., and, when bolted together, formed a ring nearly 12 feet in diameter. The ends of

each segment were milled so as to ensure a good bedding and in order to make the circle absolutely true. The machining was carried out by special milling tools curved to the shape of the finished ring.

As illustrating the suitability and softness of the metal for machining purposes, the following result of planing a number of column bases 22 inches long by 18 inches in width may be mentioned. A cut was taken ⅝ inches deep by 3-32 inches wide, "Express" tool steel being used, but after the work was completed the steel tool was found to be in as good a condition as it was previous to commencing the machining of the casting. This example is sufficient to indicate the satisfactory results which may be obtained with other castings, such as general engineering castings (both heavy and light), bed plates, pipe specials, columns, wheel centers, etc., all of which are being turned out and machined according to specification.

It may be interesting to compare the chemical composition of the direct metal from which the column bases already referred to were produced, with the same metal run into pigs and then passed through the cupola, excluding any foreign scrap in order to make the comparison as complete as possible. The result is shown in the analysis given on the next page.

MISCELLANEOUS DIRECT BLAST FURNACE CASTINGS

Commenting on these results it will be noticed how near the furnace compares with the cupola metal in many respects, especially noting the combined and graphitic carbon, the sulphur and manganese, the silicon being

A HEAVY ROLLING MILL CASTING

ANALYSIS OF METAL

	Pig Metal Per Cent	Cupola Metal Per Cent
Combined carbon	faint trace	0.075
Graphitic carbon	3.081	3.006
Phosphorus	1.734	1.584
Sulphur	0.004	0.068
Silicon	2.800	1.866
Manganese	0.216	0.180
Iron by difference	92.165	93.221
	100.000	100.000

N. B.—Phosphorus varies from 1.10 to 1.87 per cent. approximately, unless special means are used to reduce the same beneath these limits.

well within workable limits up and down, as indicated by previous experience.

Differences in commercial varieties of iron may be assumed to be the result of the substances in association, whether metals or metalloids constituting the impurities. Our study must be the effect of these impurities upon one another and upon the iron in relation to their preponderance, and we can simplify the problem if we find by practice that we can reduce the number of these to a point at which they appear to be negligible quantities. Taking the case of direct-cast iron, it is indicated by practice, so far as Northamptonshire ores are concerned, that both manganese and magnesia generally occur in such small and uniform quantities that they may safely be neglected. Sulphur, again, found so controllable in the fuel, can be easily dealt with; phosphorus in a great measure can be reduced to very reasonable limits, except for some special purposes.

We are left, probably, with silicon, combined and graphitic carbon, upon which highly important changes can be rung in relation to the allied metal, and I rather anticipate from previous experience that in the control of these three the desired results can be obtained.

There appear to be certain small determinate limits with the carbon, both combined and graphitic as well as silicon, inside which one has to keep, to maintain a sound, solid, readily machined casting; any great divergence in the proportion of these foreign ingredients would appear to impress on the iron too great a measure of each of their distinctive qualities. For instance, high silicon may produce shrinkage with brittleness; combined carbon too high,

SOME SPECIAL PIPE SECTIONS

would produce too great hardness; excess in graphitic carbon, want of solidity and blow-holes; whilst a soft, solid, fluid metal is the result of proper relations. In my own practice, keeping within the limits to which I have incidentally referred, my endeavour is usually to keep the combined carbon particularly low by its conversion in some cases into graphite in the presence of sufficient silicon.

In venturing upon these remarks, there are many practical details which must not, of course, be lost sight of in producing direct metal and delivering it at the point where it is run into moulds. Some of these are,—a hot metal obtained by fusible mixtures and not high heats, which can be regulated at the furnace; a metal of the right liquid consistence, not too fluid or sluggish (this point is to be arrived at by furnace mixtures); a grey slag of correct chemical composition, and formed on acid rather than on basic types, and having a near fusibility to that of the cast iron formed, so as to admit of ready separation and retention of graphite. And further, to facilitate reliable results, the furnace manager should keep the blast furnace as free as possible from irregularities in temperature and scaffolding; indeed, personally, I have found that the nearer one works to a correct and scientific method, the more one avoids the hundred-and-one errors and difficulties into which the rule-of-thumb-practioner is plunged.

In conclusion, I would suggest that in generally comparing the direct with the cupola castings, each ought to be fairly judged on their merits; it is just as easy for the unskilled manipulator to produce an inferior casting from the cupola, in fact easier, than from the blast furnace. Sulphur alone in the coke or in the lining of the cupola, or inferior scrap, may ruin results effectually; therefore the second running is no possible guarantee, per se, to the buyer of the quality of the casting which he is to receive. On the other hand, I be-

lieve any discredit which has been brought upon direct casting has been to a large extent justified by want of the necessary knowledge and skill in manufacture. Speaking from my own experience, I shall be quite content for a good direct casting to be tested beside one from the cupola made from the same metal,—machined or subjected to any similar test. I feel convinced it will be found, treated rightly, that there is little to choose between them in the purposes for which cupola casting is generally applied.

The writer is indebted to Mr. W. Bassett Lowke for the excellent photographs illustrating this article.

AMERICAN NAVAL ORGANIZATION AND THE PERSONNEL LAW OF 1899

THE FIGHTING ENGINEER AND THE FIGHTING MECHANIC

By Rear Admiral George W. Melville, U. S. Navy, Retired

It may not be amiss to again explain here that the Personnel Law, enacted on March 3, 1899, provided for the consolidation of the line and engineer corps in the United States Navy. The officers of the engineer corps were transferred to the line and given new commissions as line officers with actual rank. The basis of the law, and the consideration that led to its adoption, as stated by Admiral Melville in an earlier issue of this magazine, was the demonstrated fact that to have a successful Navy every line officer must be a thorough engineer.—The Editor.

IN the February issue of this magazine there was a brief editorial reference to an article by Admiral S. B. Luce, U. S. Navy, in the "North American Review," entitled "A Plea for an Engineer Corps in the Navy." This article must have attracted a good deal of attention on account of the importance of the subject as well as the naval reputation of the author. It probably surprised readers who were at all familiar with naval history that this fine officer of the "old school," who probably would not claim to be even an amateur engineer, should appear as the champion of engineering in the Navy; but for that very reason it emphasizes his sincere desire for an increase in the general efficiency of the Navy, which he recognizes as impossible if such an important branch as engineering is allowed to fall into the neglect which has certainly marked its administration on shipboard for the last few years.

Every engineer in the country who has any pride in the success of the naval branch of the profession has been filled with sorrow at the prospective extinction of really skilled engineering in the Navy, and it is well known that during the remainder of my term as Engineer-in-Chief after the passage of the Personnel Law, my annual reports called special attention to this danger. The present incumbent of the office, Admiral Charles Whiteside Rae, has done the same. It is, therefore, a source of much satisfaction to find Admiral Luce joining the ranks of those who are pleading for the rehabilitation of efficient professional care of the machinery of our great warships.

From my point of view, however, the details of Admiral Luce's scheme are not in accord with the trend which recent progress has taken, and it seems to me he is entirely mistaken in some statements, so that it may be profitable to consider the subject as viewed by one who, until three years ago, was an active factor in naval engineering and the personnel connected therewith, and was a member of the Personnel Board which devised the scheme under which the

United States Navy is now working.

Let me say, in the first place, that the plan of combining the engineer officers with the line, came as a surprise to me, as my proposition, when my views were asked, was for an increase in the numbers of the Engineer Corps to provide an adequate force of officers, and that they should be given proper military rank with a title plainly indicating it. Nevertheless, after careful discussion and consideration, I gave my vote for the plan of amalgamation, and I still believe, as my official reports repeatedly stated, that the scheme, if administered with an honest desire to make it a success, will give us a highly efficient Navy. The evident intent of the Personnel Law, to my mind, was to make every line officer primarily an engineer, on which basis would be engrafted the military and executive training, all going to make the accomplished naval officer needed to perform efficiently the duties required at the present time.

That such an officer would be well described by the term "fighting-engineer" seems to have been evident to most of those who studied the problem. The authorship of the term has been ascribed by some to President Roosevelt, without whose active interest and great tact the report of the Personnel Board could never have been agreed upon, and by others to Congressman Foss, whose remarkable grasp of naval affairs and great parlimentary skill made possible the enactment of the Personnel Law. In any event, they and other careful students of naval conditions certainly never dreamed that one who is carefully trained to perform the specific duties coming upon the modern line officer could be fairly called a hybrid, a jack-of-all-trades, and other disparaging terms. And why not a fighting engineer as well as a fighting sailor? Why the term fighting engineer, when used only in connection with naval affairs, should suggest an army engineer is remarkable, and could hardly have been believed but for the fact that Admiral Luce says it had this effect on him.

It must be very evident from a little thought about his essay that his ideas on naval education have been strongly influenced by concentration on the careers of the great naval commanders. Undoubtedly a study of their history is illuminating, but there is danger that it may lead to overlooking the fact that, for each of these great leaders, there are many hundreds of average officers who are really the ones for whom we must provide. Even a casual study of history shows that the eminence of the "lords of the deep," as of the great captains on shore and the leaders in civic affairs, is almost independent of their education or training. They become great with slight help from good systems and in spite of bad ones. The qualities which make them great are inherent. In other words, we do not need to worry over plans to provide geniuses; they will come under any system. We do need, however, to consider carefully and provide adequately for the average officer. He can be made efficient by a good system, and will be ruined by a bad one.

It should be recognized frankly that the average officer, performing routine duty, has a comperatively simple task. It is necessary for him to be well educated and to be thoroughly familiar with the details of his *materiel* and know how to keep it in order, but he is not required to be a designer of ordnance or machinery or to be a great international lawyer. The experience of many years has shown that, among the large number of officers, there will always be some whose natural aptitude and ambition will lead them to specialize along particular lines, and to qualify themselves by study and research for expert work as designers, investigators, or lawyers.

This has always been the case with ordnance, which, by the way, is essentially a branch of mechanical engineering, and, as far as manufac-

ture is concerned, no more military than any other engineering work which is to be used in warfare. No course of instruction for four years given to boys of average ability could possibly turn out such adepts as Admiral Luce's article seemed to contemplate. What the course at Annapolis should do (and I believe it does) is to provide young officers with a sound education, having in view the particular work called for in the Navy. The case is quite different from that of the technical schools in civil life. In them, it is not known what the exact work of the pupil will be, even in such a school as Stevens Institute of Technology, which limits itself to mechanical and electrical engineering. Thus Annapolis has the great advantage that its curriculum can be laid out to accomplish specific training along definite lines.

The real efficiency and skill of the officers must come from their practice in the performance of duty after graduation, and it is at this point that we find the cause of the inefficiency in engineering which is pointed out by Admiral Luce, which I deplored while still in office, and which my successor is compelled to bring to the attention of the Navy Department. When the Personnel Law was passed, all the younger engineers were required to fit themselves for general line duties, and it was understood that the same requirement would be applied to the younger line officers. The requirement was made specific for the engineers, because, prior to the amalgamation, they had not been examined in ordnance, navigation, and seamanship. There had always been an examination in steam for the line officers, and it was stated and generally agreed that this examination would be made adequate for the changed conditions. However, examinations do not give knowledge or experience; they only apply a test.

The young engineers, almost without exception, were at once given deck duty, and quite rightly, but, alas, the other side of the case was not so thoroughly attended to. Some of the young line officers were assigned to engineering duty, and, of these, some did excellent work. But there was nothing systematic for the whole body. We cannot blame these young officers for not becoming skillful engineers if they have no opportunity to acquire practical experience by actual watch-keeping and overhauling the machinery.

It seems very clear to me that the success or failure of the existing system in the Navy lies almost absolutely in the hands of the older officers. They are charged with the administration and with the assignment of duties. The ideals which they hold up are the ones which the younger men follow. If they believe that the efficient officer of the present, who handles mastless steamers, should be a skilled engineer, just as they once believed that the deck officer of a frigate must be a fine sailor, they have only to emphasize this view to their subordinates, and they will soon remove all cause of complaint.

It has been pointed out by such close students of history as President Roosevelt and others, that the scheme of the Personnel Law is analogous to that which took place in the seventeenth century when the soldier and sailor were amalgamated into the naval officer. Admiral Luce does not agree with this. He thinks a closer analogy is that of the days of the trireme, when the motive power was oars, which were usually manned by slaves or malefactors, and the fighting was done by soldiers who. except in time of battle, were really only passengers. He speaks of the importance of the commander-in-chief being a fine seaman on account of the importance of seamanship in manoeuvring, but thinks that, as the machinery will take care of the movement. the commander need no longer be an expert with the motive power.

Apparently he is so busy in thinking of Nelson, who was an accomplished sailor, that he forgets Blake,

who never knew anything about sails, but was, nevertheless, one of Britain's greatest naval commanders. No one has ever dreamed that the admiral in command is to perform the duties of the fleet engineer, or that the captain is to be the chief engineer also, but our past experience has shown cases innumerable where trouble would have been averted and much better results secured if the admirals and captains had been in their earlier days engineers by education and training. Break-downs have occurred because captains would not listen to the warnings of the engineers. If they had once been engineers themselves they would have appreciated the recommendations, or, if in doubt, could have satisfied themselves by inspection.

The most remarkable thing about Admiral Luce's essay is his view that the engineers, whom he considers of great importance, should be carefully shielded from military influences during their education, and his allegation that the old "line and staff" fight (which was happily ended by the Personnel Law), was caused by the education of the young engineers at Annapolis. It would seem obvious even to a layman that the best results would come from giving all the members of a military organization a military training as far as possible, and I do not believe there is any doubt that the experience of the past forty years has proved it. The strife in the Navy began long before any of the engineers went to Annapolis, and so far from the joint education causing or increasing the strife, it was very noticeable to me that the conflict decreased rapidly as more and more of the engineers were graduates.

I can attribute the Admiral's views on this point only to the many years which have elapsed since he was a junior officer and thus personally subject to the annoyance. He had become a commanding officer before the first engineers went to the Naval Academy at Annapolis. It is very doubtful if the amalgamation could have come for many years if it had not been for the feeling of comradeship and mutual esteem which arose from an education, largely identical, at the same alma mater. One of my former assisstants, who is now out of the service, recently wrote to me, appropos of the old strife:—

"When I left Annapolis this feeling was still somewhat acute, and I have still a keen recollection of attempts to humiliate me by a line officer who avowed himself an 'engineer-baiter.' This was, however, largely a personal defect of this man, and, as time passed, such a thing would have been impossible; good feeling was so prevalent that a man who avowed such sentiments would have been shunned by his own corps. I am proud to count among my best friends many line officers with whom I have been on duty, and to bear testimony to their kindness and consideration, which often materially lightened the burden of exacting duty."

So much has been said about the failure of the Personnel Law that it must be emphasized that, as far as engineering is concerned, it has really not been tried at all. When all the young officers are encouraged to qualify in engineering, and, say, ten classes have really become fairly skilled engineers, then will be the time to say whether or not the law has failed.

It is worth while to consider briefly the grounds on which the Personnel Board and Congress felt that amalgamation was justified. In the early days of steam propulsion, it was considered as purely auxiliary to the sails as motive power, and was used only in calms and in entering and leaving port. It was perhaps natural that the engineers and the machinery should receive scant recognition, which was what they actually did get. At that time the propelling machinery was the only kind not worked by hand. Naval progress, however, slowly but surely abolished sail

power and made necessary very powerful and complicated machinery, requiring a large force for its efficient care and manipulation.

In many of the large, fast ships of to-day, the chief engineer is in command of a larger force than the entire complement of an old-time cruiser. This meant that the engineer officers, to be efficient, must be good executives and disciplinarians. Along with this growth came the advent of huge guns, which are complicated machines; torpedoes, which are machines and nothing else; and electric power and lighting.

In the American Navy, the line officers were responsible for all of these, though the engineers were usually called in if there was serious derangement or break-down. Evidently, if the line officer was to care for all this machinery efficiently, he must of necessity be an engineer, no matter what his actual title. It is thus very plain that the duties of the two sets of officers were daily becoming more and more alike. To make them identical, the line officer needed more engineering, while the engineer needed more experience in general executive and administrative duties.

The great benefit of having all officers available for duty of any kind appeals to every student of naval affairs. In the "North American Review" for December, 1898, the lamented Jack Philip, who commanded the "Texas" at Santiago, in the Spanish-American War of 1898, gave his views at length, and commended the then proposed system as greatly strengthening the commanding officer in his administration.

The same reason which led to the amalgamation in the seventeenth century is the one which led to that at the end of the nineteenth, the obvious absurdity of carrying around a lot of officers and men who, except in actual battle, might almost as well be going through drills—their chief work in peace times—on shore, because if there is to be a strict line of demarcation between the warrior and the mechanic, it ought to be complete, giving the mechanic all the machinery of whatever kind to care for. So little room is there for the old-fashioned "sailor man" on a mastless war vessel that one of the recent secretaries of the United States Navy actually considered, for a time, filling the complement of our battleships, other than the engineer's force, largely with marines, keeping perhaps a score of sailors for helmsmen, quartermasters, and coxswains. It is not intended to imply that our line officers at present do nothing but drill the men, but if the military side of their work is to be the only one of any importance, we would drift back to the days of the Spanish Armada.

The importance of having all the officers "fighting-engineers," and all the seamen "fighting mechanics," was well pointed out more than ten years ago by Fleet Engineer Quick, of the British Navy. He did not then dream of a complete amalgamation, but his scheme had the same basic idea. He proposed that the marines should be replaced by mechanics and firemen, so that sentry duty and infantry drill would occupy about one-third of the enlarged engineer's force, every man taking his turn for about a month at a time. As he very cleverly expressed it,—"I am planning for the day of battle and the week afterward."

In other words, that fleet which has the largest force of skilled mechanics will be ready the soonest to renew hostilities. It must be obvious, too, that the same line of reasoning holds good for the day of battle. The complicated mechanisms which are now controlled by the deck officer can be kept in better order and more readily rehabilitated if he is an engineer and his men are mechanics.

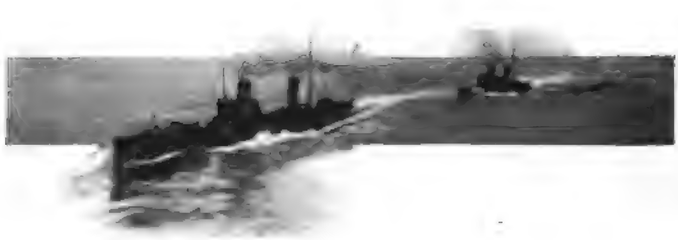
In our day the world of business and industry moves so rapidly and is so quick to respond to new conditions that we are perhaps apt to forget that navies are essentially conservative. The officers are a specially

selected body of men, and the nature of their duty makes them a class apart. Esprit de corps, which is so vital to the efficiency of a military body, inevitably tends to resist change, and it is a fact that nearly all the improvements have come from the outside and have often been compelled to fight hard for a chance to prove their merit. It should not be a matter of great surprise, therefore, that the radical change in the organization of our Navy has not, in a short seven years, been worked out thoroughly. President Roosevelt truly said that the change was evolution and not revolution, but it is nevertheless a distinct and marked difference in system.

My work as engineer-in-chief would have been much easier for a time, if the old régime had continued. I needed only a few more competent engineers. This would have made the personnel side of my duties easy, as I could count on efficient care of the machinery by skilled men. I worked loyally, however, for the new system, though it was not of my devising, and I believe that if all other officers of high rank had done the same we should now be merely perfecting details instead of discussing the system as a whole.

This change was brought about from the inside of the Service, and I believe its essential principles are correct. It may be that it was begun too soon, and it may be that changes in detail will be necessary; but some such scheme is bound to come. Unless I should live to the age of the venerable Haswell, the father of the steam navy, I cannot hope to see the ultimate solution with everything running smoothly; but I have no doubt that, however they may be designated, the naval officer of the future will be a "fighting-engineer," and the seaman a "fighting-mechanic."

My friend, Luce, and all others who have studied the subject, are agreed that skilled engineering is in great danger of disappearing from the Navy. The country will not stand many such disasters as that on the "Bennington," and, if the proper organization of the Service cannot be arranged by our own people, Congress will undoubtedly take the matter in hand under inspiration from the outside.



ELECTRICITY IN ELEVATOR SERVICE

THE RELATIVE ADVANTAGES OF ELECTRIC AND HYDRAULIC EQUIPMENTS

By S. Morgan Bushnell

DURING the past twenty years the development of the modern steel building has introduced an entirely new element into municipal life. The traveler in the great capitals of Europe, in Rome, Paris, Berlin or in London, will find that the business blocks, even in the central parts of these cities, are seldom more than six or seven stories in height. In America the city of Boston has enacted laws fixing a limit to the height of the buildings, so that they do not exceed ten or twelve stories. The two typical American cities, however, New York and Chicago, seem to have abandoned all idea of controlling the height of buildings and the owner of each lot seems to be at liberty to install upon the lot a tower of any height which may please his fancy, or which, in his opinion, will be financially feasible.

The question as to whether a municipality should limit the height of buildings within its precincts opens up a large field for argument on both sides. Without entering into the merits of this question, we find that there still remains the fact that a new type of building has been developed, constructed largely of steel and tile, and that along with this new type of construction has been developed a system of elevator devices without which the tall steel building would be commercially impossible.

The two most modern types of elevators are the direct-connected electric elevator and the hydraulic. Both types have firm advocates, and there has been a great deal of discussion as to their relative merits, both having their advantages.

The hydraulic elevator was the first to become developed for passenger service and for a long time was preferred in high-class construction. Step by step, however, it has been driven from its position, until to-day probably 90 per cent. of the elevators sold for general use are electric machines.

In order to get definite information as to the relative merits of electric and hydraulic elevators, the writer recently collected records of the operating costs of a large number of elevators in the city of Chicago. The elevators in this list are for the most part of moderate size, running from 5 to 25 H. P. These records show an approximate efficiency on the part of the electric elevators about twice that of the hydraulic elevators using electric pumps.

The following data on five office buildings using the larger drum-type electric elevators in Chicago are typical of American office building service:—

McVicker's Theatre Building	Total car miles per month, 553.2; k. w. hours per month, 1215; k. w. hours per car mile, 2.19
Republic Building	Total car miles per month, 1601.2; k. w. hours per month, 5525; k. w. hours per car mile, 3.45.
Rector Building	Total car miles per month, 1909.8; k. w. hours per month, 5525; k. w. hours per car mile, 2.89.
Silversmith Building	Total car miles per month, 1409.1: k. w. hours per month, 3976.7; k. w. hours per car mile, 2.82.
Western Methodist Book Concern	Total car miles per month, 902.8; k. w. hours per month, 2909.4; k. w. hours per car mile, 3.22.

These data are the result of taking a careful record of the number of trips made at various times during the year, and the exact record of the actual kilowatt hours as shown by a Thomson recording watt-meter. The average of these records gives a consumption of 2.91 kilowatt-hours per car-mile. This checks very closely with the data secured in other cities as to the consumption of current in operating passenger electric elevators for office building service. For example, in a paper prepared by Mr. Thomas E. Brown, of New York City, for the International Engineering Congress at St. Louis, in 1904, reference was made to six installations in New York City, using drum-type electric elevators. The average consumption per car mile of these elevators was 3.19 kilowatt-hours. If we average this with the data given for the Chicago buildings, we will have an average consumption for elevator service of about three kilowatt-hours per car mile, in cases where the drum-type electric elevator is used.

Turning now to hydraulic elevators, we find that in the Chicago Savings Bank Building, there are four hydraulic elevators, operated by means of electric pumps. These elevators average a little over six kilowatt-hours per car-mile. Let us compare this with the result in other cities. Referring again to Mr. Brown's paper on passenger elevators, we find the data of twenty-one installations using hydraulic elevators. Two of these elevators are operated by electric pumps and average a consumption of 5.9 kilowatt-hours per car-mile in current. The balance of the elevators are supplied with water by a steam pump and the average water H. P.-hours per car-mile of these elevators is 6.37.

As it requires nearly a kilowatt per H. P. to run these pumps by motors, we have the average result on these installations at practically the same, or six kilowatt-hours per car-mile. We are therefore justified in saying that the power required to operate hydraulic elevators for passenger purposes in first-class office buildings will average about six kilowatt-hours per car-mile, when reduced to an electric basis, and the power required to operate electric elevators of the drum type will average about three kilowatt-hours per car-mile.

In other words, the results as shown by careful tests on these typical office buildings confirm the results shown by the records of over a hundred smaller elevator installations, namely, that the efficiency of the electric drum-type elevator is about twice that of the hydraulic elevator when the comparison is made on the basis of using central station service. This is not surprising in view of the fact that the electric elevator requires power only to overcome the inertia and friction of the elevator and at the same time move the difference between the average load and the load at any one time, as this type of elevator is supposed to be counterbalanced for the average load. In the hydraulic elevator practically the same power is required to operate the elevators empty as to operate them when loaded to their fullest capacity, and under these conditions we would naturally expect less efficient operation.

A great deal has been said as to the relative mechanical efficiency of hydraulic elevators as compared with other types of machines, and some engineers have claimed a mechanical efficiency for the hydraulic elevator above 75 per cent. or 80 per cent. The term "mechanical efficiency," to the average person, is somewhat misleading. The owner of a building does not care particularly what the individual friction losses are in moving the mass of an elevator, plus columns of water, chain counterbalances, and the like. What he wants to know is the amount of energy required for the actual work done.

Figuring on this basis we find that the net commercial efficiency of even

the most modern elevators runs far below this. Let us take, for instance, an electric elevator of the drum type operated in a modern tall office building. Let us assume that each trip averages six persons, carried from the bottom to the top of the building. This is more than the average, but we will make this assumption in order to give the elevator every advantage in the estimate.

As already shown, the best of modern drum-type electric elevators will average about three kilowatt-hours per car-mile or four H. P.-hours per car-mile in ordinary practice. This includes not only the trip going up but the trip coming down. Therefore, in one round trip, the elevator will have lifted six persons, who are assumed to weigh 1000 pounds, half the distance traveled; in a travel of one mile it will have lifted 1000 pounds half a mile, or 2640 feet. This will give as the lifting work done during one car-mile of travel, 2,640,000 foot-pounds. Four H. P.-hours would be 4 x 33,000 x 60 equals 7,920,000 foot-pounds. In other words to do 2,640,000 foot-pounds of work by the best type of modern electric elevator would require 7,920,000 foot-pounds of energy, giving an efficiency of 33 1-3 per cent.

As we have already shown that the energy per car-mile is about twice as much for the hydraulic elevator as for the electric, we have the net lifting efficiency of the hydraulic elevator about one-half of 33 1-3 per cent. or 16 2-3 per cent. This estimate is, of course, based on the assumption that six persons are carried during an entire trip, but anyone who has traveled in elevators running under a regular schedule, as is the custom in modern office buildings, will know that this estimate is far too high.

In many buildings there are probably not over three people in an elevator at any one time on an average during the day. During the rush hours of morning and evening, of course the elevators are filled, but at other times during the day very frequently not more than two or three people start from the bottom, and they will probably leave the elevator before it has gone very far. Therefore it would not be surprising to find that in a large majority of elevator installations the actual net lifting efficiency with electric elevators does not exceed 20 per cent. and with hydraulic elevators 10 per cent. under ordinary working conditions.

There is no doubt that a great advance has been made in the economical operation of elevators, but no one would say after seeing this showing, that we have reached the limit of improvement. As far as actual energy is concerned, the advocates of the electric elevator clearly have the advantage. The hydraulic elevator salesman, however, makes this claim, —he advocates the use of a high-duty steam pump and claims that this pump, working with high-pressure steam, provides sufficient exhaust steam to go a long way towards heating the building and that the cost of generating the steam for heating the building is nearly equal to the cost of generating steam for the pump and also for heating the building.

The question of using extra exhaust steam for heating enters into the problem only when the hydraulic elevator is compared with an electric elevator run on central station service. Where the electric elevators are run from an isolated plant in a building, the exhaust steam from the engines which operate the dynamos can of course be used for heating the building in the same manner as exhaust steam from hydraulic pumps.

From the foregoing data, which show the electric elevator to be nearly twice as efficient as the hydraulic, it is evident that an engine and dynamo plant must be very inefficient indeed not to compete successfully in connection with electric elevators with the hydraulic equipment. As a matter of fact, where there is a considerable lighting and miscellaneous

power load, the elevators can run very largely on the reserve overload capacity of the dynamo and engine, inasmuch as the power used is very intermittent. Of course there is an objection to running elevators in connection with lights on account of the likelihood of a variation in the lights. This can be offset, however, by the installation of a small storage battery which will respond very quickly to any slight lowering of voltage.

But furthermore, the electric elevator, in the nature of things, is especially fitted for economical use on central station service. The small plant of six or seven elevators, operated at intervals throughout the day, makes an unsatisfactory load from the standpoint of economy, but when six or seven elevators are increased to seven hundred elevators, all operating on a single central station system, the intersecting peaks of the load lines become practically a single straight line and the elevator load becomes nearly as continuous and even as that of an exhaust fan or refrigerating plant. For this reason the elevator service is charged for by the large central stations at prices similar to those which they use for steady power. Hence, the elevator which may be uneconomical when operated from an isolated plant, will become very economical when operated from the main central station.

A great many isolated plants have realized this and the central station companies frequently have applications for elevator power from plants which claim that they can produce their own electricity for light and general power economically. Furthermore, the connection of electric elevators to the central station system enables the majority of buildings to dispense entirely with a high-pressure steam plant and very greatly simplifies the problem of operating the building.

The operation of a low-pressure steam-heating system for an office building is almost as simple as the operating of steam heat in a private residence; it requires very little engineering ability. The demand for heat is not subject to sudden and excessive changes, as is the case with light and power, and it is therefore easy to have a slow and gradual fire which will be free from the dense clouds of smoke that are seen frequently pouring from the chimney of a power plant when sudden demands are made upon it.

The saving of space in a basement is another advantage of central station service, and it is along this line that the electric elevator has especial claims over the hydraulic, in that the elevator mechanism occupies comparatively small space and can be entirely placed upon the roof of a building if it is so desired. Where hydraulic elevators are used, the engineer frequently advances the argument that he is required to operate a high-pressure steam plant anyway, and that it would require very little additional labour and expense to put in a dynamo and run the entire lighting and power for the building.

Furthermore, until the owners of large buildings adopt the policy of installing electric elevators, it will always be more or less of a difficult matter to demonstrate the advantage of central station service for large office buildings, and while some buildings will adopt central station service, others will use their own plants. If the day ever arrives when real estate men become convinced of the advantages and reliability of the electric elevator, there will be no further difficulty in convincing them of the economy of central station service.

A few years ago the advocates of hydraulic elevators based their claims largely on economy of operation. To-day this claim has been largely abandoned, but in place of this has been advanced the claim that the electric elevator is not capable of as high speeds as is the case with the hydraulic. There is a measure of truth in this

claim, but when we remember that the best types of drum elevators can now be operated successfully in any height of building at speeds of from 300 to 350 feet per minute, and when we find some makers of electric elevators claiming a speed of 600 feet per minute, we realize that there is very little force to this argument. The best practice in modern hotels, apartment buildings and office buildings to-day does not exceed 350 to 400 feet per minute and is usually under that figure. The minute the speed is increased beyond that point, we begin to have difficulty in stopping the elevator at the exact level of each floor, and as a result there are delays while the elevator attendant is adjusting the height of the elevator car. Many people are more or less nervous when traveling in very high-speed elevators, and taking it all in all there is little or no saving in the extremely high speeds.

The question therefore narrows itself down to a matter of expense. Which type of construction, all things considered, is the most economical in the long run? The electric elevator salesman claims that the cost of repairs and renewals is very much less with the electric machine, as nothing is required but the drum mechanism connected to an electric motor, while the hydraulic elevator requires in addition to the motor or steam pump, which is the prime mover, an elaborate system of piping and cylinders. The hydraulic elevator salesman, on the other hand, claims that while the hydraulic elevator mechanism is more elaborate, it is more substantial and less likely to get out of order.

As far as the writer is enabled to judge, neither side has very much advantage, as isolated instances can be cited from both sides, which favour the contention either one way or the other. The question therefore reduces itself to one of first cost and operating cost. As far as the published bids of the elevator companies are concerned, they go to show that for a medium-sized plant the hydraulic equipment with a high-duty pump requires nearly double the investment required for the electric elevator where the current for the elevator is used for central station service.

It has already been shown that the operating efficiency of the electric elevator is about twice that of the hydraulic, and when we add to this the enormous difference in first cost, the argument becomes very strong in favour of the electric elevator with central station service.

In view of such figures it is not surprising that during the past ten years the sale of electric elevators has increased from a very small proportion to nearly 90 per cent. of the total number of elevators installed, and if we should judge the future from the past it would not be extravagant to expect that during the next ten years the tall office buildings which have thus far used in most cases the hydraulic machine, will eventually adopt for the most part the electric elevator.

NEW BUSINESS FOR ELECTRIC CENTRAL STATIONS

FROM ADVERTISING, SOLICITORS, AND LETTERS

By John Craig Hammond

Mr. Hammond's article is the fourth of a series which began in the April number, telling of how to get new business for electric central stations. Others will follow in succeeding numbers. In addition to these specific business-getting articles, however, the central-station manager will find profitable suggestions in others in these pages, dealing with electric light and power applications outside of factories,—in the home, for example, in the city's streets, in places of amusement, in a score of branches of varied service. We refer particularly to such contributions as the one entitled, "The Electric City of the Future," in the April number; "Extending the Uses of Electricity: Its Applications to Domestic Service," in June; "Electricity in Elevator Service," elsewhere in this issue; and others of similar kind, to appear in later issues. These all help to direct attention to sources of possible revenue. They are "New Business" pointers of a valuable kind.—The Editor.

WHY are electric light and power plants erected and equipped? Some people—some consumers—think to see how fast a meter can be made to run. Take a virgin district. Surely the first thing to be thought out is how much revenue can be secured on the investment. Can it be made to pay? There are few central stations to-day that have been erected for the fun of it. Most every stockholder wants to make some money on his investment.

The city or town can be induced to take light. A certain number of people know that an electric switch is a handy thing; some merchants know they can make their shops more attractive by good light. These people have observed and know from observation. And there you stop.

It seems almost impossible, but is true nevertheless, that it has been only during the past few years that central station managers have awakened to the fact that they had something else to do besides buying new motors or trying to get a new make of lamp at less cost than the old one. These are important points, of course, for good service comes before new business.

But why is it that central station managers have waited for the public to come to them, rather than go to the public? Why not try to have an electric fan installed in the home or office? Why not try to induce a woman to use an electric curling iron or chafing dish? Why not try to induce people to use porch lights, the blacksmith to run his forge by electric power, the merchant to hang out an electric sign or outline his building or windows with electric lights?

Sell more current and you increase your revenue. Isn't that what every central station manager should want to do,—to increase the revenue and thereby increase the profits of the stockholders? It certainly is, but very few central station men gave this much consideration a few years ago. To-day, they are being awakened to the fact that a commercial plant means a money-making plant.

There is only one way to increase the revenue and that is to get more business, and there is only one way to get more business, and that is to go after it. What is the best way to get the increased business?

There comes the rub. You have a difference of opinion. One central

station manager will point with pride to his results and the next manager will try the same methods and fail. Why fail? The reasons are many and complicated. Advertising experts will rush into the breech, and with a wonderous display of type will declare that they know the only way —the proper way—the best way. Perhaps they do. If they do, they ought not to stay in the advertising business; there is more money in other quarters for them.

To the best of my knowledge, Denver, Colorado, was one of the first central stations in America to go to the public. Henry L. Doherty, upon taking charge of the Denver Gas & Electric Company, had certain ideas that were aborning. He knew he wanted to increase the revenue. He knew he had to sell more current to get the revenue. He was not sure how to get the business. He groped around in the dark for a time. He wrote letters, he talked to advertising men, but still he was not satisfied. He added a few hours to his working day and made a study of advertising. He became a student of the art of getting new business, more business from old consumers, and making the old consumers satisfied.

He spent a good deal of money in trying. He found that he could increase the business, but he could not do it with a profit, by trying one method. He wanted another method. He found that what worked in Denver was not always good in some other city in which he was interested, unless certain modifications, certain points were taken into consideration. The electrical world knows of Mr. Doherty and his efforts. Some men don't agree with him. They were numbered by the scores a few years ago, but they grow less every day as he demonstrates that his theories are right—that new business was just as important as good service.

It is impossible to give even an outline of the advertising schemes used by Mr. Doherty within the bounds of one article or even a half a dozen articles. I can, however, give some ideas, some suggestions that may be of benefit to other central station men. Mr. Doherty early realized that he must have some one to go deep into the question of new business. He came to the conclusion that advertisements alone would not bring the results, but that solicitors must be brought into use,—men educated to the business.

It was a long and bold campaign that Mr. Doherty outlined. As the result of his forethought, of his investigation, he is to-day not a manager, president, and consulting engineer of plants only, but an operator and an owner as well. His results came from the adoption of new business methods, and that certainly should be a goal for most any central station manager,—to own and operate plants of his own.

The conditions in Denver—where Mr. Doherty first used his methods —were about as follows:—The company was supplying the wants of any one who came to the office. That was about all. A new business department was organized. A few wide-awake active men were secured. First, however, the conditions had been canvassed with care and a plan agreed upon. It was decided to divide the city into districts and make a solicitor manager of each district. These men had to be educated into talking the advantages of an electric sign, for example. Meetings were held every morning under the care of Clare N. Stannard,—and, by the way, Mr. Stannard in all probability has turned out more good new business managers than any man in the electrical field to-day. He is still in charge of the Doherty school—a school that gets results in Denver, and is getting results wherever the men are used.

A careful canvass was made of the city. Each house was listed. What the tenant or owner had in the shape of gas or electricity was noted with care. What he used and what he

could use, such as a porch light, fan, more lights, was noted. The names were transferred to a card system and then the advertising campaign was started.

For example, it was found out that 20,000 people did not have porch lights. What would it cost to get those 20,000 people to use them? How much revenue could be secured if they burned, say, three hours every evening? It is not difficult to get the answer. How much would it pay to spend getting that business? For example, say each porch light would bring $5 a year additional revenue. To get that $5 increased business, would it not pay to spend, say $1? Mr. Doherty said it would, and it did.

There were 2,000 merchants who did not use electric signs. Get them to use electric signs. Say the revenue—gross, of course—would be $300 a year from each sign. It would be a satisfactory increase to get that much money coming into the company. Would it not pay to try? It certainly would, and it did.

Why am I using so much space to try and prove that it pays to advertise? Because there are scores of central station managers who are still in doubt to-day. They have not been made to see.

The solicitors of the Denver company reported every day at a meeting of the "New Business" department. What they had to say was taken down in short-hand and their suggestions were noted with care.

It was agreed that the public should be given every consideration. Complaints should be investigated, high bills tested, and the good will of the public secured by deserving it. Office employees were organized into an association. They were given the help of the officers of the company in bettering their condition. They were advanced as rapidly as possible; any one who showed merit was pushed along. There was the foundation of the new business policy—the officers treated the employees fairly, honestly, fired them with a spirit of improvement. It was drilled into every employee that he was a servant of the public—that the company must look to the great public for its business. If a woman complained, no matter if she was a dyed-in-the-wool crank, be polite—try and find out her trouble—no matter if it did take time.

Such methods soon counted with the public. They took notice. Instead of mutterings and curses there was a good word now and then. Solicitors were educated to talk on their feet by daily meetings, by joint meetings once a month with the engineers and other employees. There were dances and card parties, trolley rides—any thing to increase a feeling of friendship among the employees. Get that spirit and it will reflect in the treatment given to the consumer.

A solicitor might be ordered away from a home or an office. He did not give up. He went back. He used diplomacy; the advertising department assisted by letters. Any work or new construction for a consumer was investigated. A letter was sent asking whether the work was all right, whether the service was good. A man called to investigate, too. In other words, the public and the company were getting acquainted. True, it took time and it cost money. But the results made up for all this.

So, without the proper foundation on the part of the officers of a company, without the right spirit among the employees, don't start a "new business" department. Get your solicitors first, and get them right. Then get your advertising. What kind?

I know wise experts who will scratch their wise heads and, with thoughtful mien, will say, use this, don't use that. Now, those experts don't know. Take my word for it—they don't. True, they think they do, but while they may lead you right sometimes, they may lead you the wrong way more often.

I know one expert who declared that a certain kind of letter, written to a prospective customer, was the worst kind of folly. Now he was right—if he had tried to use that letter, say, in Boston. He was right if the letter had not been used at the time it was used and in the way it was used. The "style" of letter was good for a certain time, under certain conditions. The objecting expert did not know the conditions. With a sweep of his hand he took a broad condition, he did not look into facts, he did not turn up the edges to see what had gone before, or what might follow; he said it was wrong and so it must be wrong. But it was not, as results demonstrated. That letter, declared worthless, brought sixty-three answers for every hundred sent, and that is pretty good.

Start an advertising campaign to-morrow, map it out a year in advance, and I will go on record that it will not be carried out as planned. If it is, you won't get results. Local conditions govern, remember that first and all the time. Let me say it again,—your local conditions count, first, last, and all the time. Say that over to yourself, paste it in your desk. Don't let people tell you otherwise. They don't know.

What are you going to do? If an advertising expert takes up your work,—he may be anywhere and do it if he uses ordinary sense,—make him take into consideration your local conditions.

In Denver, street car cards paid for a time. So did painted bill boards and signs. Letters pay all the time, if you write the right kind of letter. And I am going to close with a bit on letters. Theater programme advertising will pay once where it will fail ninety-nine times. Daily newspaper advertising will pay under the following conditions:—Change your advertisement; never use the same one twice; use smaller space and often rather than a big display once a week. Tell your story in such an interesting way that people will read it because it is interesting and because you have something to say. "Cute" ads. won't get more consumers for you.

Booklets will pay sometimes,—so will cards. But conditions, details of what you have done, what you are going to do,—they come first all the time. I can write an advertisement that will bring certain results in one town; it might be a failure in the next town, because it would not fit. True, you can make a broad advertisement for newspaper use, for example, and it can be made to pay. But again don't trust to luck. Be sure.

There is hardly any known form of advertising that the Denver Gas & Electric Company has not tried. Some paid—some was a flat failure—some brought steady returns. You must work your advertising and your solicitors together—keep in close touch—work with the solicitor—send out your mail matter so that your solicitor can follow it.

Let the solicitor come to you and tell of his failures. I recall a case in Denver. A solicitor had been ordered out of a store time and again. At last letters were sent to the merchant,—letters such as the expert already mentioned said were no good. They struck the merchant the right way. They were followed up every few days. The solicitor called again. As he was about to say "good morning," one of the series of letters was laid on the man's desk by his office boy.

"Excuse me a moment. I want to see what new thing that fellow has to tell in his letter to-day," said the merchant.

He read the letter, turned to the solicitor and said:—"I see it your way. I give in. Put up the sign."

Now that merchant would never have "given in" if he had not been followed, and if the solicitor and advertising department had not worked together.

Don't make your letters heavy.

Don't make them flippant. Get in between. Be unique to-day—don't be to-morrow. Sounds mysterious? Well, it is mysterious if you don't know how. You can learn how—if you stop and think. Make your letter interesting and don't make it a circular.

Use a 2-cent stamp. Keep the letter on one page. I know where it will pay to make a letter two pages long,—not in many cases, but at times it will pay, though not as a rule.

In the past, I wrote letters that read something like the following:—

Dear Sir:

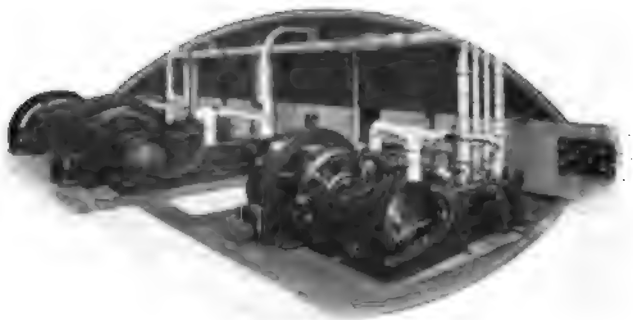
What you want to do this morning is to stop the leak in your expense. Haven't got any leaks? Oh, yes, you have. Why are we so certain, how do we know? Well, it's our business to know.

We want to help you stop the leak—that's our only motive in writing you this letter. Do you know you are using steam to raise and lower your elevator? Do you know that we can save you money by installing electric power?

We can. You are busy this morning. But, please fill in the enclosed postal card, and let our power expert explain how he can save money for you. He will call at the time that meets your convenience.

That is a "broken" letter. It will pay—that letter,—up to a certain point. But don't stick to that style all the time. It's a bit of a tonic—get some changes. Change the style, size, and colour of your letter heads. Don't overdo it with too much novelty. I know some who thought that "breezy" style was good. They are using it to-day, and they should have given it up a long time ago. Variety—but tell your story.

Advertise, but use your head.



MODERN GRINDING

METHODS AND MACHINES

By Joseph Horner

Concluded from the June Number

UNIVERSAL grinders differ from plain circular machines in the arrangements of the wheel head. Both classes of machines include parallel and angular settings of the table, but some of the plain ones do not even include the angular setting. The essential difference between the two great groups is that the wheel head lies parallel with the axis of the table in the first, while it can be swivelled to any angle in the second, which, with the swivel of the bed, permits of grinding short tapers as well as long ones. And as an internal-grinding spindle is usually fitted, the universality of the machine is available for hole grinding on revolving pieces, as well as external work. Besides this, the headstock swivels on a circular base, which makes it serviceable for tapers.

The designs of universal grinders are better known than those of some special types previously noted, and others to be mentioned, and they have been well illustrated in earlier issues of this magazine, so that they need not here be considered at length.

The details of these machines are very complete, and very elaborate. Each section is a complete study in itself,—the headstocks, wheel heads, beds, and tables, countershafts and feeds. Several great groups are marked by much individuality, so that a glance at a machine will often suffice to indicate its origin, unless, as in some cases, it is an imitation of some well-known model. Some of the principal differences in machines are these:—

The work table traverses in some; in others it is a fixture, and the travel is imparted to the wheel head. There are many differences in the fitting of the spindle bearings, both of headstock and wheel, combining provisions for lubrication for delaying wear, taking up wear, and protection from dust. One valuable feature, common to all, is the provision made for driving work either from the headstock spindle or on dead centres.

The details of internal-grinding spindles vary, as the problem of the steady running of a long spindle unsupported at one end is a troublesome one to work out with entirely satisfactorily results. The difficulty of grinding long spindles truly due to spring and the effects of heat, has given rise to numerous steady rests. The details of bed sections and swivel tables vary. Numerous are the arrangements for lubrication, and the protection of table slides from the wash of the emery-charged water. Self-acting movements and reversals embody various diverse mechanisms, as also do the self-acting arrangements for feeding to precise and extremely fine dimensions in a few of the best machines.

Universals occur in a large range of dimensions, from those of the small sizes most common in the shops to some used for grinding heavy chilled rolls,—a class of work formerly turned with difficulty in the lathe, but which is now largely ap-

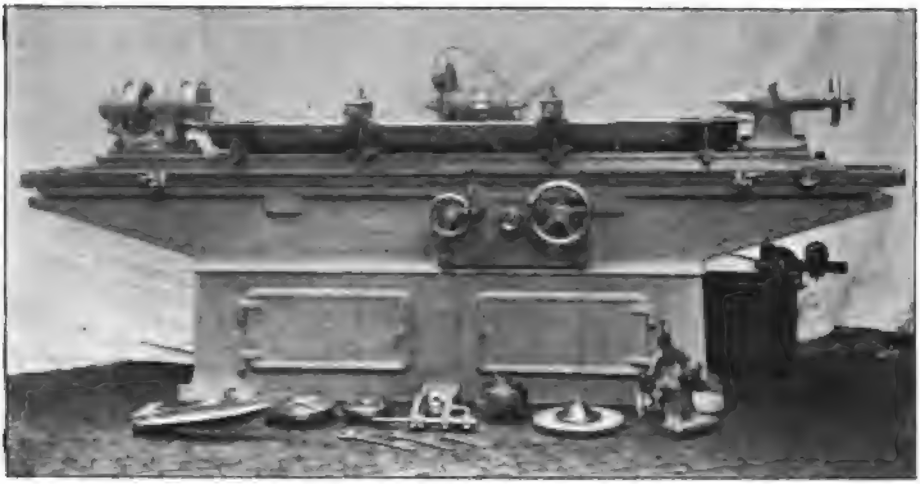


FIG. 12.—A UNIVERSAL GRINDING MACHINE BUILT BY MESSRS. G. BIRCH & CO., MANCHESTER, ENGLAND

propriated by the grinder. The machine by Messrs. Birch & Co., shown in Fig. 12, is capable of admitting work up to 14 inches in diameter by 72 inches long. It is also made with a hollow mandrel with clearance to admit shafts up to 3-38ths in diameter. This is useful for roll grinding, the work being carried on two adjustable three-jaw stays. This enables work up to 8 feet long being done on the machine. The same firm makes a series of high-class grinders.

The tool grinders stand apart from the machines already noticed in their special adaptabilities, notwithstanding that some of the elements have much in common. The differences are, however, more marked than the resemblances.

Tool grinders form three great groups,—the cutter grinders, the drill grinders, and a relatively small group as yet designed for grinding the single-edged tools used in lathe, planer, etc. The cutter grinders are generally of a lighter build than plain grinders or universals, which they resemble. With few exceptions, they are universal machines, to cover the great variety in the forms of milling cutters as well as reamers. They have traversing movements of the table, and, of course, vertical adjustments. Tables and heads swivel for tapers. Two wheels are generally carried, a plain wheel and a cup wheel, at opposite ends of the spindle. Forming attachments are sometimes fitted for cutters of irregular profile, and twist drill grinding adjuncts more frequently.

The twist drill grinding machines carry the drill on an arm. The essential feature of these is the symmetrical formation of the lips without relying at all on the workman, and the proper amount of clearance imparted behind the cutting edges. The arm is generally swivelled by hand against the wheel, but there are a few machines in which the work is done automatically. The twist drill grinders, therefore, admit of two broad classifications,—those which are hand-operated, and the automatic ones. The first-named grind one lip before touching the other, while in the automatic machines the grinding of both lips goes on uniformly during a constant rotation of the drill.

It is only recently that these last machines have been developed, and they are of exceedingly ingenious design. In the ordinary hand-operated machines the angle and the clearance of the lips are ensured by

the setting in the socket, and a hand lever operates the lips against the grinding wheel. In this apparently simple detail different firms have embodied various mechanisms in their machines for giving clearance by movements of traverse and oscillation, so that sharpening and backing off are done at the same time. In the automatic machines, which are few in number as yet, the whole of the drill-operating mechanisms is derived from the rotation of a single belt pulley driven from the countershaft.

In a machine made by Fr. Schmaltz the pulley gives motion to two sets of mechanism for the rotation and traverse of the drill, respectively. The rotation is obtained by spiral gears, the traverse by worm gears, the first spiral gear and worm being on the same pulley shaft. The driven spiral

FIG. 13.—A LARGE AUTOMATIC CUTTER GRINDING MACHINE BUILT BY FREDERICK SCHMALTZ, OFFENBACH-ON-THE-MAIN, GERMANY.—A LARGE FORM CUTTER IS SHOWN ON THE GROUND AT THE RIGHT, IN A SPECIAL FRAME FOR HOLDING IT

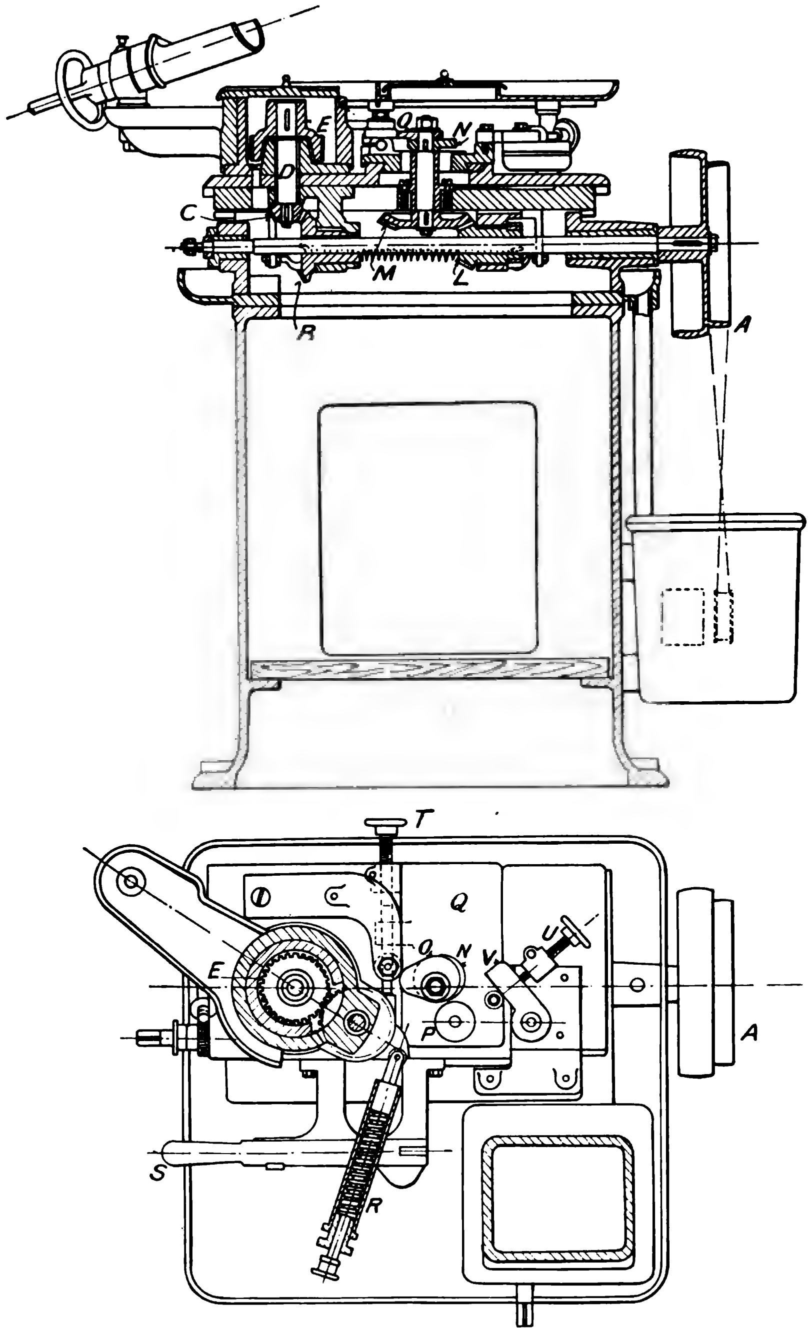


FIG. 14.—AUTOMATIC TWIST DRILL GRINDER MADE BY MESSRS. MAYER & SCHMIDT OFFENBACH-ON-THE-MAIN, GERMANY

wheel encloses the drill spindle passing through its disc at an angle. The worm wheel turns a heart-shaped cam by which the tool slide is traversed parallel to and fro against the face of the grinding wheel. As the spindle of the drill holder is set at an angle in the rotating body of the spiral wheel, the drill is carried round in a conical path.

The grinding of each lip in succession is effected automatically by an arm on the holder, wnich, coming in contact with a stop at half a revolution, disengages a spring stop plunger from a collar on the holder. The result is that the drill chuck, continuing to turn in its bearing in the body of the spiral wheel, makes half a turn until a notch on the opposite side of the collar just named engages with the spring plunger, and is locked for the grinding of the other lip, and so on until the lips are finished.

In a new design by Mayer & Schmidt, illustrated in Figs. 14, 15, and 16, automatic movements are derived from a single belt pulley *A*. This drives the rotational and sliding movements of the drill respectively in the following manner:—The bevel wheels *B* and *C*, driven from the shaft of *A*, rotate a pin *D* on which a spur wheel *E* is mounted, and the latter drives through another spur, and bevels *G* and *H*, Fig. 15, thus rotating the twist drill held in its self-centring chuck *J*. The hand wheel *K* at the back clamps a point support which holds up the drill end to position.

A reciprocating motion to carry the drill lips across the wheel face is desirable, in order to insure even wear of the grinding surface, and this is produced through another train of wheels, commencing with *L* (on the shaft of *A*) driving *M*. A couple of eccentrics or cam-discs, *N* and *O*, are keyed on the shaft *M*; *N* presses against a roller *P*,—Fig. 16,—and thus causes the slide *Q* to reciprocate; a spring *R* produces the return stroke. The box in which *R* is held may be unlatched by the handle *S*, allowing *R* to be swivelled out of the way, so that the drill may be withdrawn from the wheel, the entire holder being swivelled around the axis of the pin *D*. The screw *T* is for adjusting the cutting angle, by swivelling the holder as much as necessary around the axis of *D*.

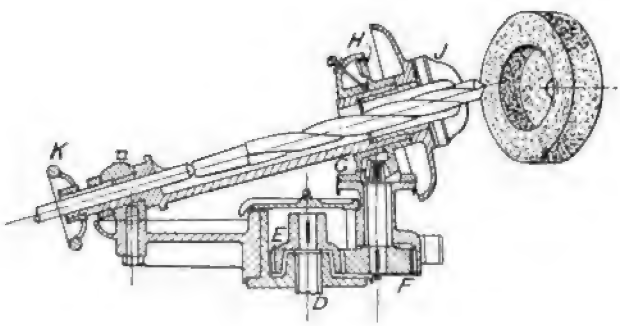


FIG. 15.—AUTOMATIC TWIST DRILL GRINDER, DETAIL MADE BY MESSRS. MAYER & SCHMIDT

The backing-off is effected by a motion to and from the grinding wheel, produced by the cam *O* coercing the slide crosswise through the medium of a roller. The amount of clearance is controlled by the screw *U* altering the angle guide *V*, which bears against a small roller in the slide, seen in plan.

An automatic feed is imparted as the lips are being ground to shape, by a fine worm gear on the end of the shaft of *A*, imparting a slow movement to a screw feeding the

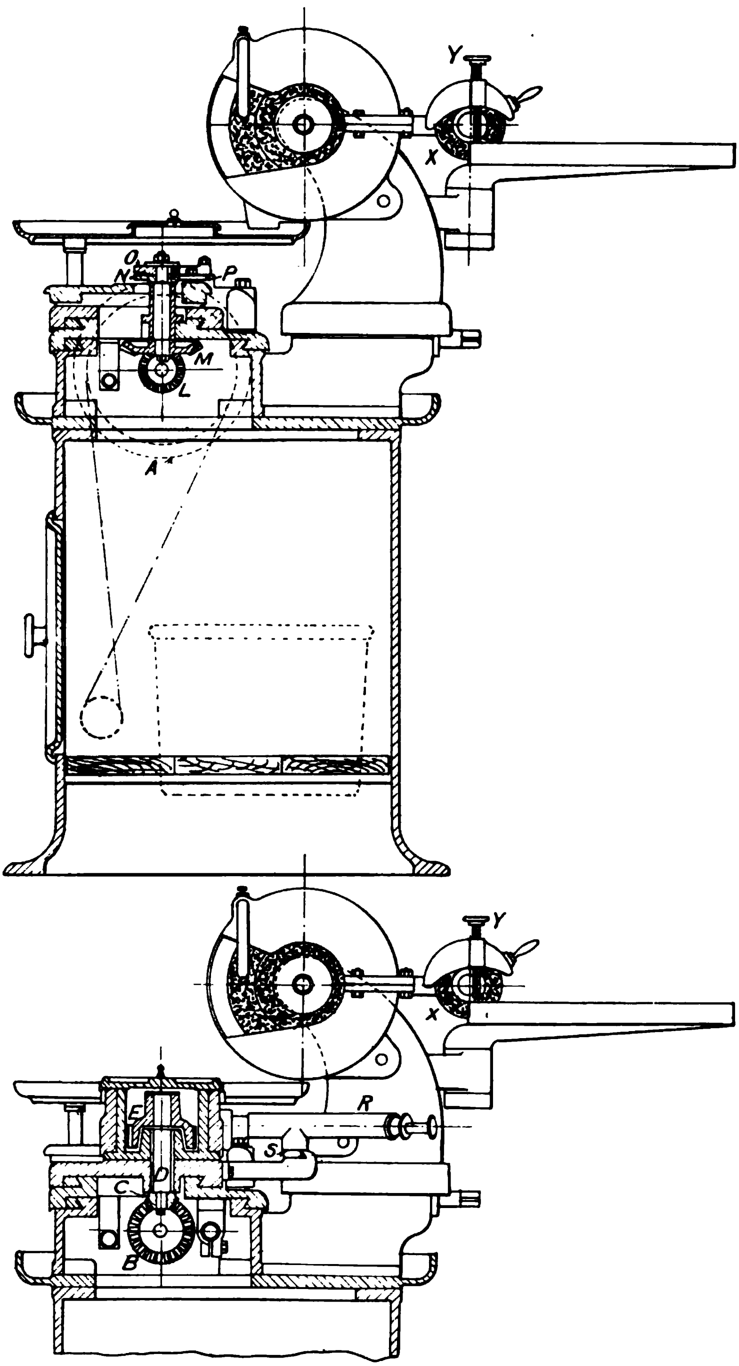


FIG. 16.—AUTOMATIC TWIST DRILL GRINDER MADE BY MESSRS. MAYER & SCHMIDT

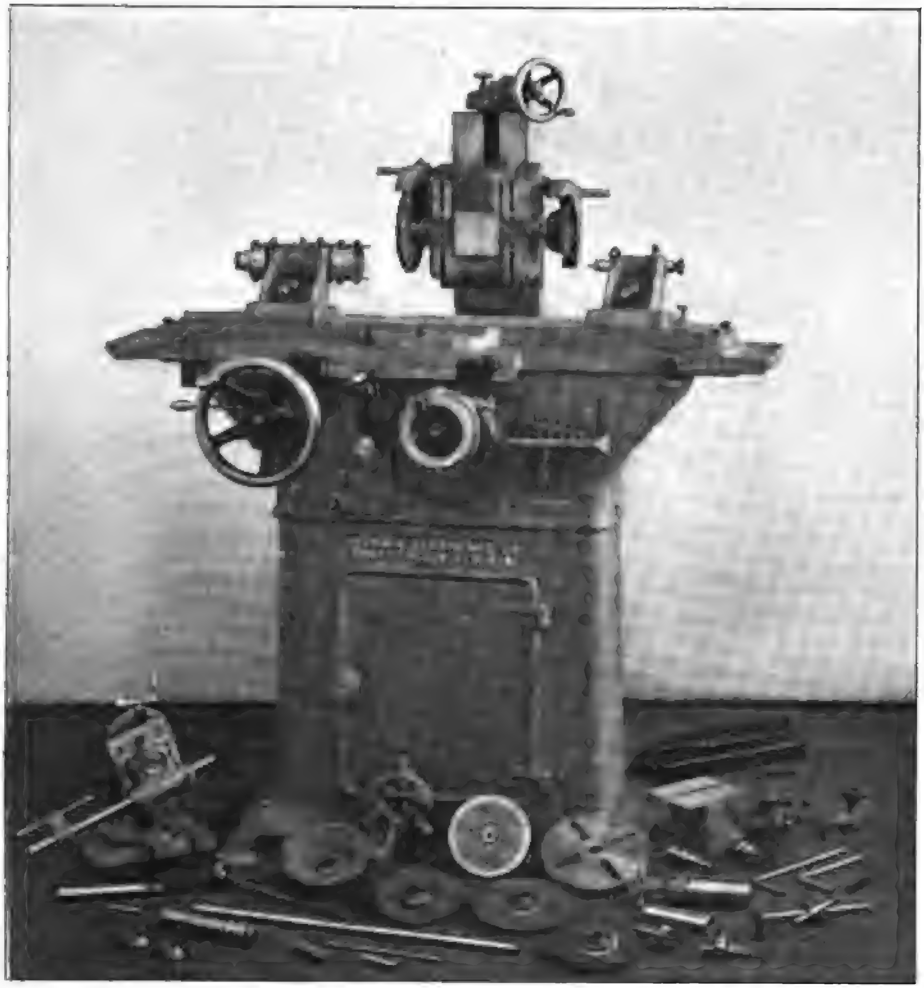


FIG. 17.—A UNIVERSAL AND TOOL GRINDING MACHINE MADE BY THE BROWN & SHARPE MFG. CO. PROVIDENCE, R. I., U. S. A.

drill up towards the grinding wheel. A device for thinning the drill points is provided, in the shape of a separate thin wheel *X*, located over a V-holder in which the drill is laid; the wheel is brought down with a handle, uniform depthing being ensured by the stop screw *Y*. A complete system of water guards and trough is fitted, a pump also being provided.

The grinders for single-edged tools are represented by three principal types. First, there is that comparatively large group in which the tools are held in the hand, or gripped in some kind of holder and traversed across the face of the wheel by hand, or by means of a screw and hand wheel. The arrangements for setting to angle are crude and wanting in precision and uniformity. The other machines are represented by the Sellers, Fig. 22, and the Gisholt designs, in both of which absolute precision is embodied, so that any number of similar tools can be gripped and ground exactly alike for top, front or side rake, and with square or convex edges. The displacement

of the older methods by these machines or by others embodying similar methods is only a question of time.

There are many special machines that lie outside the principal groups, and which number many examples. Knife-grinding machines are a large class; saw-grinding machines another; belt polishers, another; and cup and cone grinders, ball grinders, and others swell the list. Better known than some of these are the machines for grinding tramway wheels, the manufacture of which has assumed such vast proportions of late years. One of these by Messrs. Pollock & Macnab, Ltd., of Manchester, is shown in Figs. 20 and 21. The driving takes place from the fast and loose pulleys at the left, with speed reduction through spur wheels, by which a separate countershaft is made unnecessary. The axle shaft is not centred on a point centre, but is held in and driven by a self-centring chuck, and at the other end in a veed bearing. The obvious advantage is that the wheels are ground up truly on their own axle journals, or reground truly, if the journals should wear. The grinding wheels are driven by fast and loose pulleys, and are carried on compound rests fixed on pillars, with all adjustments, including that of the pillars themselves, bodily to and from the axles. The emery wheels have guards with chutes for dropping water into the tank formed in the base plate.

Lastly, we have some examples of combinations of grinding apparatus with that of the cutting tools, as the old grinding wheel or the lap was used in the lathe. One exam-

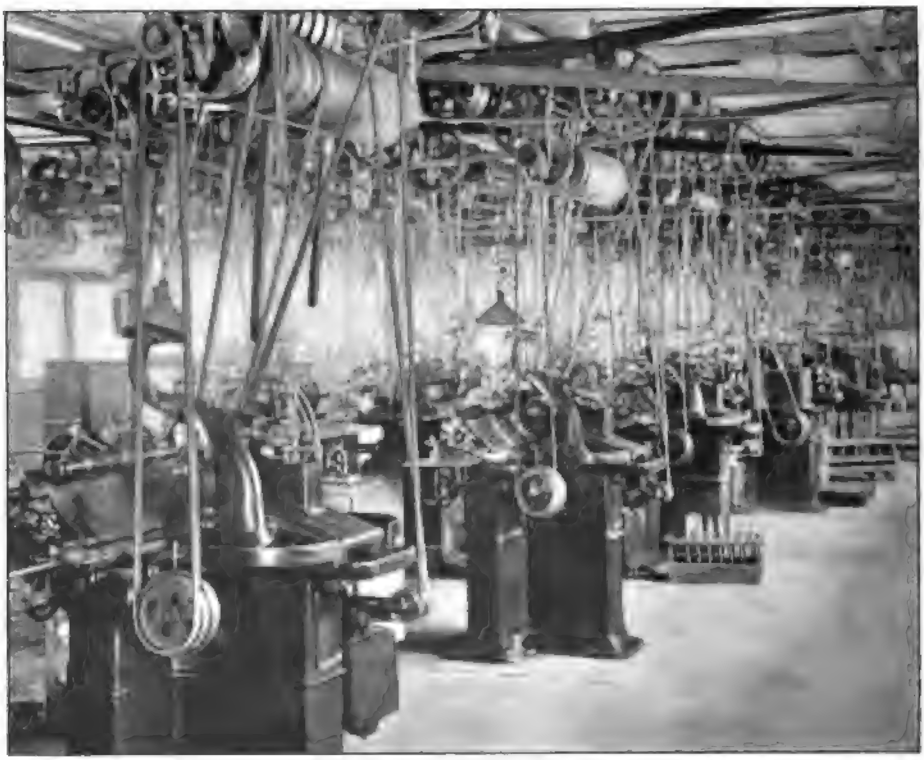


FIG. 18.—IN THE GRINDING DEPARTMENT OF THE BROWN & SHARPE MFG. COMPANY'S SHOPS AT PROVIDENCE, R. I., U. S. A.

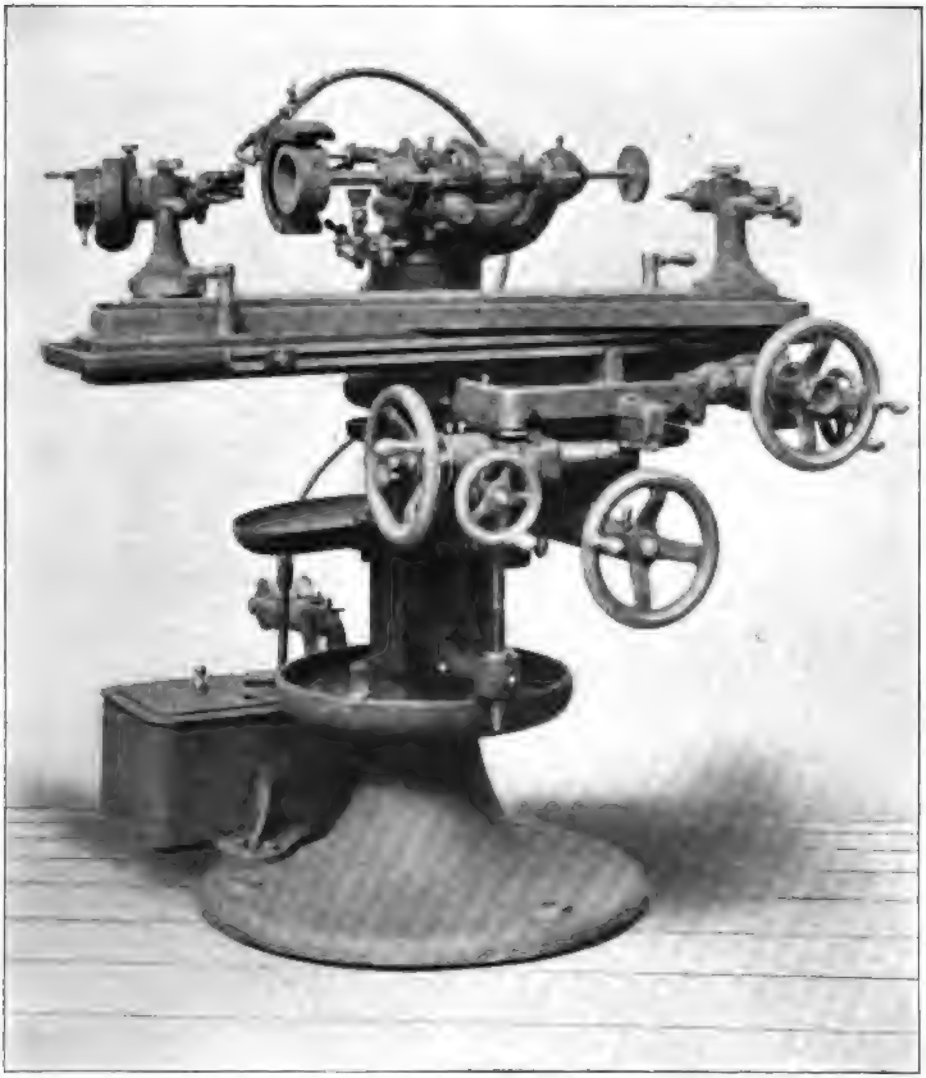


FIG. 19.—A UNIVERSAL CUTTER-GRINDING MACHINE, CAPACITY, 10 INCHES DIAMETER BY 27 INCHES LONG, BUILT BY ALFRED HERBERT, LTD., COVENTRY

ple is shown in Fig. 23, built also by Messrs. Pollock & Macnab, in which each portion is suitably designed for its work, instead of involving, as the old combinations did, some makeshifts and corresponding disadvantages. The machine is capable, first, of doing ordinary lathe work between centres or on the plate. It has also a special rest rigged up for boring the bosses of car wheels. It will also grind the treads of two wheels at once, and turn the axle journals. Lastly, it is fitted with a crane and pulley blocks having head enough to lift an axle shaft clear of the grinding rests.

One feature by which the grinding practice of the present is distinguished from that of the past is the increasing employment of water. Dry grinding is done less and less,

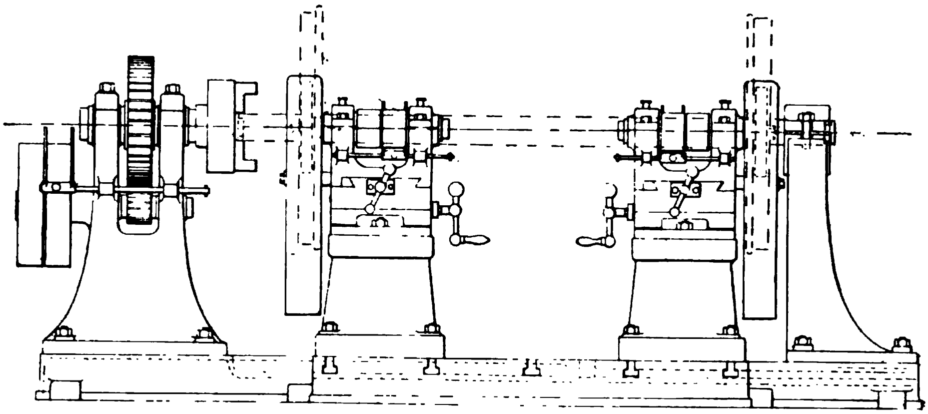


FIG. 20.—TRAMWAY WHEEL GRINDING MACHINE MADE BY MESSRS. POLLOCK & MACNAB, LTD., MANCHESTER, ENGLAND

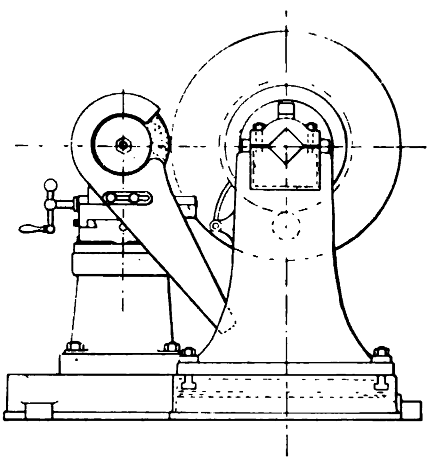


FIG. 21.—END VIEW

and water is used both more frequently and more freely. This is a matter of great importance. Water in abundance keeps the work cool, and this lessens the risk of distortion, while it permits also of heavier grinding being done. Dry grinding is but a survival from an earlier period, when the cementing material of emery wheels became softened in water; but that condition is no longer a necessary one. Dry grinding has been retained because the older machines were not properly designed either to bring the water in sufficient volume to the work, or to convey it away with the emery particles in suspension. On the other hand, dry grinding was worse for the bearings, and for the attendant than wet grinding, though in the best modern machines the protection of bearings is as perfect as it is practicable to make them.

The grinding wheel itself has been largely responsible for the extension of the practice of grinding. I use this term because large numbers of wheels are not now made of emery, but of carborundum, which is harder and more durable. It is but a short time since the manufacture of this material was commenced at Niagara Falls, and now carborundum wheels are in regular use in many countries. Their intense hardness and durability more than counterbalance their extra cost.

Besides this, vastly more care is now exercised in the selection of suitable grades of wheels for different kinds of jobs,—soft or hard, coarse or fine, giving judicious preference generally to narrow wheels for traversing, and in taking lighter cuts for fine work. The grindstone in a shop is of one grade for all classes of work; sometimes two or three grades of emery wheels are expected to cover all the work of a shop in various metals and alloys. But fifty or sixty are available,

though a dozen will generally cover all requirements. Much of the art of the grinder consists in selecting the most suitable wheels for work to be done under certain conditions, and this can be acquired only by experience. A good man is always learning something about the wheels and the work they will do that books could never teach him.

FIG. 22.—TOOL GRINDING MACHINE MADE BY MESSRS. WILLIAM SELLERS & CO., INC., PHILADELPHIA

Grinding falls naturally under two broad heads,—that of a formative, and that of a corrective process. The first-named coincides, to a certain extent, with the roughing-out work of the machine tools; the second, with their fine finishing processes. Until recently the former was a negligible factor. Latterly the removal of a cubic inch of material per minute by grinding has been given as a remarkable performance, the ideal which makers and users of grinders should emulate. There is no question of coarse feeding here, but one of high speed and of keeping the work cool, and the selection of suitable free-cutting wheels. The case stands, therefore, on a different footing from the coarse cutting of the single-edged tool. It is more like that of the milling cutter, in which the depth of cut is always minute, but in which economies are secured by speeding up, which is made practicable by abundant lubrication.

But there is no finality in any-

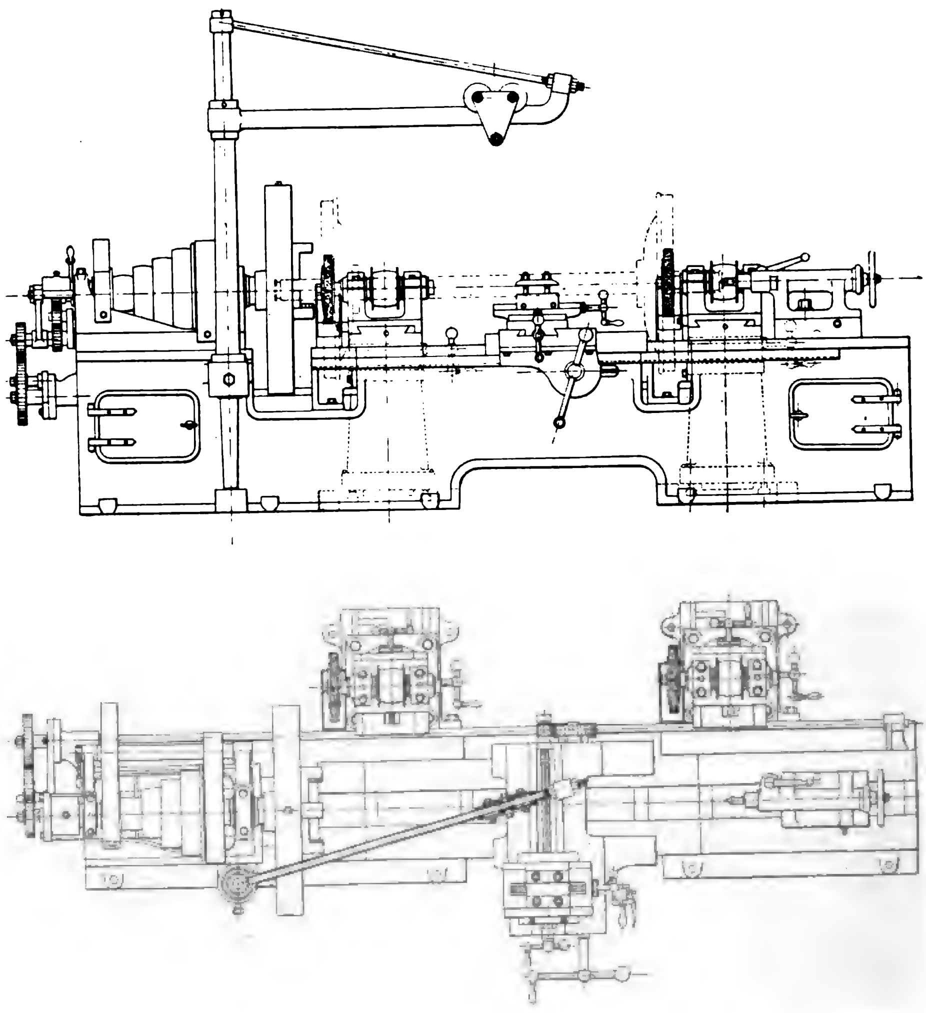


FIG. 23.—TRAMWAY WHEEL GRINDING MACHINE, ALSO ADAPTED FOR TURNING AND BORING THE BOSSES OF WHEELS, MADE BY MESSRS. POLLOCK, MACNAB & CO., LTD., MANCHESTER

thing in the machine shop. Just as the grinder has been invading the province of the lathe and planer as a formative or roughing tool, so the value of its performance from this point of view is being lessened by the high-speed tool steels. The work of these must apparently discount the advances made in rough-grinding, due to the enormous discrepancy in their results. It is no longer a question of grinding versus carbon-steel tools, but grinding against high-speed steel tools. This fact affords another illustration among many of the rapidity with which radical changes take place in the modern practice of engineering.

But grinding as a corrective process occupies a position which is unassailable, and here we must anticipate that its greatest extensions will take place. In this, of course, we must include tool grinding, which

corrects and restores the edges damaged by service. The field occupied by this is ever being extended, involving cutter grinding in all its forms, twist drill grinding, and that of single-edged tools. In a few machines the operations are entirely automatic, but in most, constant attendance is necessary. But the great advantage of these machines lies in the precise character of the results obtained and the absolute uniformity of the cutting edges, which the old hand-grinding could not produce.

Current Topics

AFLOAT and ashore the two most noteworthy engineering achievements to be chronicled for the past few weeks have been the completion and first trip across the Atlantic of the great Hamburg-American Line steamship "Kaiserin Auguste Victoria," and the opening for service of the Hotel Belmont, in the city of New York. To the uninitiated, building a hotel may not seem like extraordinary engineering enterprise; but the hotel structure of advanced type bears little semblance to its modest progenitors. Essentially it is, of course, only a house with creature comforts within, but these have been so amplified in time that to-day they represent the exercise of engineering talent of wide variety and of the first order. Extending down below the street level five stories, and above the surface twenty-three stories, as the Belmont does, the structural problem, to begin with, demanded the civil engineer's treatment. Within was the province of the mechanical and the electrical engineer. Power, lighting, heating and ventilating, transportation, water supply, fire protection, cold storage, and a multitude of other requirements combined to make the power plant of the hotel a fair-sized central station. Seventeen hundred horse-power boiler capacity and 1200 horse-power electrical generating outfit are included in the equipment. The ice plant has a daily capacity of 75 tons. The "vertical rapid transit" system,—elevators,—is on a scale never before attempted, even in a city of sky-scrapers like New York. There are sixteen electric elevators and ten electric dumb waiters, while pneumatic delivery tubes run everywhere, from basement to roof, with discharging pockets on every floor. A garbage incinerator plant and a vacuum cleaner system also are among the conveniences, and

on the roof, 368 feet above, a wireless telegraph station will be installed. Eighteen of the upper floors are devoted to guest rooms. There are nearly seven hundred of them, and every one is provided with outside windows, artificial ventilation, telephones, electric clocks, and electric hair curlers. The temperature is regulated throughout the entire building. Bath rooms, provided with filtered water, and large closets open from nearly every room. From the artist's point of view, the Belmont is a thing of beauty. To-day it is claimed to be the leading hotel of the world.

SIMILARLY, the "Kaiserin Auguste Victoria," for the time, ranks as the most remarkable structure afloat, the biggest ship and the most luxuriously appointed one yet put into service. In many respects she is a duplicate of the "Amerika," also belonging to the Hamburg-American Line, and described at length in this magazine in December, 1905; but the later ship is larger and has several new features, prompted by experience with the sister vessel. A skyscraper afloat is the not inapt characterization of the new ship. Nine decks tower one above the other, with a depth from boat deck to keel of 87 feet, and elevators, therefore, naturally form part of the equipment. With a length of 700 feet over all, and a beam of 77 feet, the "Kaiserin," at full load, will have a displacement of 45,000 tons. An à la carte restaurant, under Ritz-Carlton management, a gymnasium with much cleverly devised apparatus, a flower shop, electric light baths, and many other unusual features are here again represented, having previously been introduced on the "Amerika," but an entirely new adjunct, the inspiration of Captain Sachse, chief inspector of the Hamburg-American Line, is a palm garden, with growing plants and bubbling fountains, and beautiful illuminating night effects. Wireless telegraphy, of course, is provided for on board, and two daily papers are printed, one in German,—the "Atlantisches Tageblatt,"—and the other in English, "The Atlantic Daily News." Twin screws, driven by 17,000 H. P. engines, propel the ship at a speed of about 18 knots.

NO branch of applied science is to-day making more rapid progress or more lasting advances than that of electric lighting. For several years attention has been largely focussed upon the problem of high-speed transportation and long-distance communication with and without wires, so that the admirable work of physicists and central station engineers in the direction of improving systems for the generation, transmission, and distribution of electricity for illuminating purposes has, at times, almost been overlooked. We are fast coming to realize, however, that illuminating engineering is a technical specialty in itself, and at gatherings of central station managers the progress of the art comes home to one with telling force.

IT is not many years since an incandescent lamp having a so-called "efficiency" of 3.1 watts per candlepower represented the limit of manufacturing achievement in commercial sizes, and at the present time 3.5 watt lamps are exceedingly common. A large number of lamps from municipal plants were recently tested for efficiency by one of the large electric illuminating companies, when it was found that in practically every case the efficiency was poorer than 3.1 watts,—the standard lamp of the company in question. For certain kinds of service, especially where long life is of more importance than high efficiency, the 3.5 and 4-watt lamps have a useful field; but in installations where the lamp

can be well treated, and where the cost of current is more than nominal, something better is needed.

It is very essential that a lamp should be capable of being turned out in sizes not greatly in excess of 16 candle-power if it is to take a place in general commercial service, but it is hard to get low candle-power and long life in a unit of very high efficiency. The metallized carbon lamp has an efficiency of from 2.5 to 2.75 watts per candle-power, on the average; but at present the size of the smallest individual unit, 50 candle-power, is inconveniently large for service where a single 16-candle-power lamp will give satisfaction. It is probable that within a year or two the metallized carbon lamp will reach a 2-watt efficiency, and a 20-candle-power unit is soon to make its appearance. This will be a notable advance, for the consumer will get much more light for the same money,—certainly from 20 to 40 per cent. more,—and the tendency will undoubtedly be to increase the list of central station customers more than enough to offset the decrease in revenue. These points were well brought out by Dr. Louis Bell at the fourth annual meeting of the Association of Electric Lighting Engineers of New England, in an address upon incandescent lighting progress. The tantalum lamp already gives an efficiency of 2 watts per candle-power, but it is still, comparatively speaking, a rarity in most places, is not very satisfactory on alternating-current circuits in point of life, and does not appear likely to come into very general use for the present.

Progress in arc lighting has been rapid of late, and in the magnetite lamp we find high efficiency combined with long life and a very simple lamp mechanism. The quality of illumination given by this lamp is probably the nearest approach to daylight which has thus far been secured. Some improvement in the electrodes is to be anticipated, but the main features of the design are pretty well established. No efficiency poorer than 0.5 watt per candle-power is considered satisfactory to-day in the most advanced arc lighting practice. These improvements in lamp economy do not mean any great saving in the cost of generating current at the central station, but in the case of city lighting they insure a better return for street illumination, and in commercial service they are sure to benefit the central station by their tendency to greatly popularize the use of electricity. The magnetite lamp will shortly be available for 110-volt and 220-volt multiple circuits, but it has the disadvantage at present of being unsuited to alternating-current service. In that class of work the Nernst and the Meridian, supplemented by the high-efficiency metallified filament lamp, seem to be the chief reliance.

Three other important subjects are now much in evidence in central station work. New business-getting is more prominent in electric light affairs than ever before; the single-phase motor is opening up fields of business previously considered unprofitable, notably in scattered suburban regions; and the rate problem is being clarified in many cities by the introduction of the so-called demand system. It is most important that the public be brought to realize that a company which charges its consumers at varying rates, does not discriminate if those charges are based upon the customer's demand and his actual consumption of energy. If the equities of the demand system of rates were better understood by the public at large there would certainly be less talk of municipal ownership in the urban lighting field.

The progress which is to-day being made in both the technical and commercial sides of electric lighting deserves the admiration of every one interested in electricity, and it is a matter for sincere congratulation that the benefits of this incomparable agent of comfort, convenience and efficient production are destined to become still more widely enjoyed by the consuming public.

A LITTLE thing will sometimes stand between success and failure in many lines of work. The following incident will serve to illustrate this point. Not long ago a sample of a new type of burner for incandescent gas mantles was tested for use in the auditorium of a church building and gave very satisfactory results. In consequence, quite a large order was placed for burners with which to equip the building, and the installation of which was to be supervised by a member of the committee having the matter in charge. When the first burner of the new lot was set up and tested, it would persist in flashing back and burning in the Bunsen tube in spite of all attempts to prevent this by adjusting the gas valve at the outlet. Several of the other burners were then tested, the same mantle being used in each case, but all with the same result,—persistent flashing back. It was then decided to test the burners at the parsonage. This was done, a different mantle being used, however. All the burners now burned successfully, and the degree of brilliancy of illumination responded promptly to variations in the supply of gas at the valve. Surmising that something had been overlooked in the church tests, they were repeated with extra care, the mantle formerly tried at the church being still employed in the renewed tests. The results were no more favourable than in the first instance. Correspondence was then opened up with the manufacturer, who at once suggested as the only possible explanation of the results obtained that the Davy wire gauze must have been omitted from the burners and from the supporting tube of the mantle used in the church tests, whereas there was probably a wire gauze in the mantle used in the parsonage tests. This, upon investigation, was found to be the case, and when the wire gauze was inserted in the tube of the burners all of them lighted up brilliantly. Now the committeeman, who is well enough acquainted with the principles of the Davy gauze in preventing the ignition of gas within its sphere, wonders that this simple explanation did not occur to him.

A NOTEWORTHY addition to the literature of engineering education has been made by the recent publication of an elaborately gotten-up volume giving "A History of the Stevens Institute of Technology," and dedicated to the memory of Dr. Henry Morton, the first president of that institution, which ranks among the best of its kind in the world. For over thirty years Stevens Institute has turned out into engineering life a yearly growing number of young men, equipped, no doubt, as well as any institution of learning can equip a man for professional work, and to-day Stevens men are found allied with engineering enterprise in many different parts of the world. A record of their achievements is virtually a record of the achievements of the school itself, and such a record is supplied by the volume in question. It makes interesting reading, tracing the development of each of the nearly 1200 graduates from early school-days to the present time,—an almost unbroken story of success. The inception of the volume came with the exercises of the twenty-fifth anniversary of the Institute, held in February, 1897, when Dr. Morton planned a souvenir book, to include a complete account

of those exercises, a history of the school, biographies of the trustees and faculty, and whatever else had a bearing upon it. Dr. Morton, unfortunately, did not live to see the completion of the work, but its programme was well carried out, and the volume, as it is, is splendidly representative of the fruits of labour intelligently directed towards the foundation work of engineering science and industry. The Stevens family,—a family of engineers,—of whom Edwin Augustus Stevens was the founder of the Institute, forms one of the several interesting chapters of the volume, concerning itself mainly with the work of Colonel John Stevens, grandson of the founder of the family in America, and of his sons, Robert Livingston and Edwin Augustus, in the early part of the last century. The development of the steamboat and the early days of the steam locomotive and steam railway, the invention of the T-rail and spike, of the elongated shell for cannon, and the building of the Stevens battery, the first ironclad vessel to be actually placed under construction, are thus successively presented, together with an account of miscellaneous inventions by members of the Stevens family, the whole forming a story of continued interest. Indeed, even this part alone would make the volume a most valuable one for reference use; coupled, as it is, with the succeeding chapters, records of the lives of members of the faculty in the earlier days of the Institute, all men of distinction in the applied sciences and arts, and the records of the younger men who followed them, the reader has before him a volume of fascinating interest. As may have been gathered from this brief notice, the book, published by the Alumni Association of Stevens Institute, at Hoboken, N. J., was intended mainly for circulation among its members, but a limited number of copies are still available for others interested in the progress of engineering education. To these the volume will prove a desirable library acquisition well worth the price.

SAMUEL SHELDON

The New President of the American Institute of Electrical Engineers

A BIOGRAPHICAL SKETCH

By Edwin H. Seaman

ENGINEERING society elections are not usually spirited happenings. Ordinarily they create scarcely a ripple of excitement; hence when the extraordinary occurs, and one of these elections becomes a contest in fact, as was the recent one of the officers for the American Institute of Electrical Engineers, it attracts all the more attention. The chief interest was centered in the presidential office, which this year went to Dr. Samuel Sheldon, electrical engineer, physicist, and educator, professor at the Polytechnic Institute, of Brooklyn, N. Y.

Dr. Sheldon was born at Middlebury, Vt., in 1862. His early education was received at the Middlebury Public School and the Middlebury High School. Entering Middlebury College in 1879, he supported himself while there by his scholarship. He won and maintained one

of the endowment prizes, and throughout the four years remained at the head of his class.

In 1883 he graduated with the degree of A.B., and immediately commenced his career as an educator by teaching mathematics at the college until 1886. In 1887 he received the degree of A.M. Although Dr. Sheldon possessed very limited means, he determined at this time to further pursue his studies abroad, and with this in view he entered the University of Würtzburg in the fall of the same year. During his first year he was selected from several hundred others of his fellow students to directly assist the eminent physicist, Professor Friedrich Kohlrausch, in his celebrated determination of the ohm for the Bavarian Government. During the next year he held the position of assistant in physics until the time of his graduation from the university in 1888 with the degree of Ph.D.

Immediately upon his return to America Dr. Sheldon was made head assistant in physics at Harvard University, under Professor Trowbridge. Here he remained until 1889, when he resigned to accept the position of professor of physics and electrical engineering at the Polytechnic Institute, of Brooklyn. This was at the time when that institution was established as separate from the Preparatory school, and it befell Dr. Sheldon to establish and develop both the electrical and mechanical departments. He not only established these courses, but also equipped the shop, mechanical, engineering, physical, and electrical laboratories. At his suggestion, the Polytechnic Institute instituted, in 1904, its Department of Consulting Professors. In this department the student meets men who are prominent in the profession and comes in touch with the practical side of his work.

As a teacher, Dr. Sheldon has been most successful. His ability to concisely present just what is essential without including a great mass of superfluous detail, makes his work greatly appreciated both by his students and fellow teachers. Since his connection with the Polytechnic Institute he has been frequently called to give testimony in both State and Federal courts, and since 1903 he has been an expert of the Swiss Department of Justice and Police. Dr. Sheldon's personality lends itself most forcibly to this class of work, as he has great power to digest all facts and to testify only such material as is directly to the point. He is, further, thoroughly self-possessed, and never gives way to personal feeling. Dr. Sheldon has also carried on an extensive consulting engineering practice since 1890, especially in electrochemical development, and has published many papers along this line.

In connection with his research work, Dr. Sheldon has for a number of years carried on experiments with static generators, and has been an important factor in furnishing material to the American Electro-Therapeutic Association. From the standpoint of recent developments concerning the nature of the process of conduction of electricity in gases, he has discovered the principle of operation of these electro-static generators which never hitherto has been thoroughly understood.

From his youth Dr. Sheldon has shown his fondness for literature. While only a small boy it is said that he obtained a printing-press and started the publication of "The Boys' Herald," of which he was the editor, printer, and reporter. This little publication was brought out monthly, and had a wide circulation. In more recent years Dr. Sheldon contributed liberally to the scientific press. He is the author of a standard text-book on "Direct Current Machinery," and joint author of another on "Alternating Current Machinery." These books are used extensively in many of the engineering colleges. He is also a generous con-

tributor to the proceedings of the different engineering societies of which he is a member. Jointly with Professor Trowbridge, he contributed material to the American Academy, their "Neutralization of Induction" being of the most importance. He has continually contributed to the transactions of the American Institute of Electrical Engineers many papers on education and electrochemistry.

It is in connection with his popular lectures that Dr. Sheldon has especially brought himself before the public of New York and Brooklyn. For a number of years he delivered courses on electricity, magnetism, and physics, both before the Board of Education and the Brooklyn Institute of Arts and Sciences. These usually were partly experimental, and were well received.

Dr. Samuel Sheldon has been a member of the American Institute of Electrical Engineers for seventeen years. He has served six years as manager, four years on the papers committee as chairman, and two years as vice-president. At the International Electric Congress held at St. Louis in 1904, he was secretary of one of the sections, and he was also a member of the Electric Jury of Awards.

He has also been prominent as manager of the American Electrochemical Society, president of the New York Electrical Society, fellow of the American Association for the Advancement of Science, member of the American Physical Society, Society for the Promotion of Engineering Education, honorary fellow of the American Electro-Therapeutic Association, member of the National Electric Light Association, and president of the Department of Electricity of the Brooklyn Institute of Arts and Sciences.

From Other Points of View

The Cost of Condensing

From "The Engineer," London

THE first thing to settle is the method of obtaining a sufficient supply of cold water. This is very far from being the easy matter some engineers think. We could cite certain very important instances of mistakes being made which were followed by much delay, inconvenience, and a surprisingly large outlay of money. Errors of the kind are not commonly met with now, but they are made, and warnings are needed. It is still a favourite theory that if a station is near a river plenty of water can be had for next to nothing. In practice, however, this is seldom the case. The station generally stands in a town, and the water in the river is often quite unfit for surface or even jet condensers. Even in the country floods will make rivers so muddy that the condensers are choked up. Again, in many places pipes cannot be laid out far in the bed of the stream, because they may be dragged up by anchors. Canals, —not in towns,—are ideal sources of supply; but it will usually be found that the water must be paid for. Finally, we have wells and cooling towers. The sinking of the wells and the construction of the towers cost a good deal, and very frequently the cooling tower has to be helped by large fans, which cannot be run for nothing.

Keeping these things in mind, it will be seen that the cost of condensation may sometimes be so considerable that it is open to doubt whether it is worth while to have it. This may be regarded as a strange statement. It is none the less true, however, and there is reason to think that, all things considered, in certain situations dynamos could be driven with more economy with non-condensing than with condensing engines. This is particularly true when coal is very cheap and cooling water very dear.

The benefit conferred by the condenser is of two kinds. In the first place, it enables steam to be used with maximum economy; in the second, it so far increases the work got out of a given quantity of steam that a smaller engine and boiler can be used. But the additional first cost of the condensing plant must not be forgotten. Now the reduction in the weight of steam used per horsepower per hour may be set forth in various ways. We may show what it ought to be in set mathematical phrase; we may talk of entropy, and hyperbolic logarithms, and so on, but the practical effect of condensing is to reduce the back pressure and useless work done by the engine. Thus, let us take the case of an engine with a single cylinder and piston a little

over 50 inches in diameter, moving at the rate of 600 feet per minute. The area of the piston is 2000 square inches, and 1 pound pressure per inch gives us $2000 \times 600 = 1,200,000$ foot-pounds per minute, or, omitting fractions, say 37 horse-power.

Now the average effective steam pressure in such an engine cylinder may be, say, 20 pounds, and the actual horse-power of the engine will then be 740. If the back pressure is 3 pounds, then the indicated horse-power will be 629. If it is 15 pounds, then the indicated power will be 185 only. But by raising the average pressure in the engine to 35 pounds, the figures would stand at total power of engine 1295, indicated power 770.

We have stated a case as favourable as possible to the condenser, but in practice the gain in power will not be anything like that stated, except under very exceptional conditions, and the reason is that the back pressure in a cylinder is always much higher than that in the condenser. With only 2 pounds pressure in the condenser it will be good practice to get down to 5 pounds in the cylinder. It is an interesting fact that while it is quite possible to get down back pressure very nearly to that of the atmosphere with a non-condensing engine, there is always a difference of some pounds between the pressure in the cylinder and the condenser. The reason why is not quite clear. The only explanation advanced is that a certain amount of time is lost in condensing the steam, and that the tubes of the condenser offer a good deal of resistance to the passage of the exhaust steam among them. Be this as it may, in practice it may be taken as proved that a reduction of 8 pounds per square inch of resistance is the most that can be secured by any condenser attached to a piston engine, save under exceptional conditions. In the case we have cited this would mean 280 indicated horse-power.

The question to be settled by the designer of the plant is whether this power is or is not worth having at the price that must be paid for it in the way of outlay on a condenser, cooling towers, and water rent. But in approaching this question we must consider whether the reduction in back pressure is or is not clear gain. In one sense, no doubt it is; in another it is not. To get the same useful power out of a non-condensing as out of a condensing engine the steam pressure must be raised, and the cylinder will be hotter than it can be when a condenser is employed, and so initial cylinder condensation is minimized. The actual result in practice may be that the steam is used with more economy when non-condensing than when condensing. Indeed, instances may be cited in which non-condensing engines are doing as well as condensing engines of no small merit. Thus, for example, a horse-power for 22 pounds of steam is not at all bad work with a compound condensing engine; but locomotives and other fast-running non-condensing engines have been run on a consumption of about 23 pounds. We are not, however, attempting to prove that the condenser is not worth having, but simply that every case should be carefully sifted by the engineer who designs steam plant, in order that he may ascertain whether all his engines, or some of them, or none of them, should be worked with condensers.

We know that the trend of engineering opinion is altogether in favour of condensation at any price, but there have always been men who advocated caution, and argued that condensation is not invariably advisable. Unfortunately, very little information derived from actual experiments is available as to the weight of steam per indicated horse-power per hour required by the same engine working with and without a condenser. This is the more to be regretted because many electric light engines of as much as 1500 indicated horse-power have been made which

can be worked either with or without condensation. It ought not to be difficult to arrive at useful figures under such conditions.

The cost of condensing water per 1000 gallons ought to be, and very often is, known with precision; nothing should be easier than to utilize these figures to excellent purpose. If a saving in coal measured in small fractions of a penny is balanced by an increase in the price paid for water also measured in fractions of a penny, then the interest on the first cost of a condensing plant may be dead loss. Instances have come under our knowledge where really huge sums have been wasted by mistaken endeavours to obtain condensing water. The waste could have been entirely avoided if the engineers designing the plant had kept in mind that, excellent as condensation is, it is not at all impossible to pay too much for it.

We may digress here for a moment to say that since we wrote we have been informed that one leading firm, making turbines of large power for electric generating stations, has found the addition of a dry air pump quite unnecessary, attaining a vacuum within one inch of the barometer with a properly designed Edwards air pump alone, the temperature of the cooling water being not much over 40 deg. F. Let us accept as a good working standard a consumption of 15 pounds of steam per indicated horse-power for a reciprocating engine, which, with an evaporation of 10 pounds of water per pound of coal, represents a consumption of 1.5 pound of coal per indicated horse-power per hour. Assume that of a turbine to be the same, but let it be also assumed that the turbine uses three times as much water for condensing as the piston engine. The first cost of the turbine will probably be less, and that to a considerable degree, than the cost of the piston engine. Will this saving balance the extra outlay for condensing plant and water? The question is one of more importance than may, perhaps, appear at first sight, and deserves very careful consideration.

The Action of Capped Armour-Piercing Shell

From the "Journal of the United States Artillery"

THE action of capped armour-piercing shell has been made the subject of an interesting paper by Engen Kodar v. Thurnwerth, a German "marine artillery engineer," of which a translation is given in the "Journal of the United States Artillery," by Captain George Blakely. In this the theory of the capping of the sharp points of heavy projectiles with soft metal is stated in a new way. Perhaps the most widespread explanation is, that the material of the cap acts as a lubricant for the projectile in its passage through the plate, and reduces the great amount of friction that occurs between the surface of the projectile and the plate opening. Were it indeed true that the action of the cap lay in nothing else than this, the advantage would hold only in the case of soft plates, where the head and body of the projectile both come into sliding contact with the plate opening, and an advantage would not be found with hard plates where there is not a sliding contact between plate and projectile. All experiments, however, show that the superiority of the capped projectile is unquestionable only with hardened plates, whereas with soft plates the capped projectile is not better than the uncapped. Another purported to explain the action on the ground that the cap took up the shock of impact like a railway buffer; in other words, that it absorbed the amount of energy which would otherwise cause the destruction of the projectile. In the essay in question the reason given is the following:—That the superior action of the capped projectile rests on the fact that the point

of the projectile is not deformed at the first instant of impact with the plate. Due to the intervention of the cap, the pressure is not confined simply to the point, but is distributed uniformly over a fairly large cross-section. The unit pressure, therefore, does not exceed the limit above which the tempered material of the projectile would be impaired. As a consequence, the point is not deformed at the first instant of impact, but pierces like a chisel into the hard layers of armour plate. At this stage the cap has fulfilled its mission and the projectile goes on its way alone and uninjured.

Concerning Electric Heating

From "The Electrical World and Engineer"

IN these days when central stations are actively looking for new business, it strikes us that a little more attention to the uses of electricity for heating would pay well. Plants here and there have been devoting some attention to the subject for a few years past, especially in connection with flat-irons, but it has not been pursued with much vigour save in a few instances. There has been much hesitation in favouring a use for energy in which full lighting rates are evidently out of place, even when rates in themselves profitable can be obtained.

There are at present available all sorts of heating appliances at reasonable prices and of good quality which would give the central stations good revenue if their use were encouraged, and the load is one which in itself has usually proved to be desirable in that it tends to level up the hollows in the load curve. Moreover, it is a use that, when once made economically possible, will persist, while some other popular uses will not. For example, the very extensive use of electric signs now evident is one that may feel severely the first incursion of hard times, as representing a fashion rather than a daily necessity of commerce. Once get electric appliances into the household, shop or factory, however, and they will stay so long as they give good and reasonably economical service. On the other hand, appliances, the practical value of which is not immediately evident, are easily displaced.

The policy of the gas companies has been very farsighted in this respect. Instead of making rates to penalize the small consumer, they have favoured him, perhaps unduly. They have made it possible by persistent and liberal exploitation, for the small consumer to be introduced on an economic basis to all manner of gas-heating appliances, and they are getting ready to raid the motor business with small gas engines in a way that may before long be felt. The moral effect of this policy is at once felt through the community. A householder who finds that a gas range is cheaper than a coal range, and that a gas log is not to be despised as an occasional auxiliary heater, will generally not think it worth his while to run an additional bill for electric lights, and he is an easily made friend of the gas engine. And that is the policy that we expect of our central station friends,—to develop every field, old and new, that promises ultimate profits, and to occupy it so fully that the other fellow cannot get a foothold. The electric heating appliance business at the prices of energy ordinarily met, cannot at present be a very large item, but in certain plants it can be made thoroughly profitable as a source of additional load. Once show a man that electric cooking apparatus and the like is wonderfully handy and reasonably cheap, and he will keep it in use and add to the station's revenue year after year. In summer and in the warmer parts of our country, this line of work can be followed up with good results, especially when the station uses hydraulic power. Some of the Southern California plants have built up quite a large

business in this way, selling energy at 3 to 4 cents per KW-hour and competing very successfully with gas at, say, $1.50 per thousand cubic feet.

Attempts at ordinary air heating by electricity have not been satisfactory at a similar price, nor is it to be expected. On the other hand, gas for this purpose fails in similar fashion, save as an occasional auxiliary. Gas heat as ordinarily used is extremely bad from the hygienic standpoint. It vitiates the air very seriously indeed, and the moisture produced by the combustion makes itself a nuisance unless there is very thorough ventilation. Of course, there are places where coal is high enough in price to give electric heating a chance. It has even now been found that electric radiators can be made useful in bathrooms, bedrooms and the like, at a cost that is not prohibitive. With energy down to 2 or 3 cents per KW.-hour, and especially when its use for this sort of work can be kept off the peak of the load, there is chance for a growing business. Of course, it is clear that there are many plants which could not profitably meet such a price. On the other hand, there are many which can and do make such quotations even for load carried over the peak.

The miscellaneous thermal uses of electricity can be carried at better prices, air heating representing the least general and most unfavourable case. We know of plenty of hydraulic plants where a thousand KW.-hours per day of off-the-peak load would not be looked at with contempt even at 3 cents per unit. It should be noted, too, that this kind of load, being mainly off the peak, does not bear heavily on the capacity of transformers or of the distribution system. At the price mentioned, electric kitchen equipment is not outclassed in economy by either coal or gas. Experience has shown that 3-cent energy is about on a par with dollar gas in cooking apparatus, and it is reasonably certain that dollar gas is cheaper than anthracite at the cost now common away from the anthracite districts. Even with energy at 4 to 5 cents per unit, the electric cooking and miscellaneous heating is on a par with the use of coal at $6 to $7.50 per ton.

Here is a field for exploitation worth serious effort. Granting, for the present, that heating on a large scale by electricity is too costly, there still remains a chance for putting in the auxiliary and miscellaneous heating appliances on a sound economic basis. The gas companies make no pretense of competing with coal for general house heating, but they derive large revenue from just the class of work here referred to, a revenue which is thoroughly available if the central station will really get after it in earnest.

Ventilation of Boiler and Engine Rooms

From "The Engineering Record"

WITH the approach of the summer, ventilation readily suggests itself as an appropriate topic for discussion. So much has been said on the subject with reference to boiler and engine rooms aboard ship, where the temperatures at all times rise to extraordinary heights, that its importance in connection with similar installations on land has almost been overshadowed. Temperatures considerably above 100 degrees are not at all uncommon during the warm months of the year in many of the basements and sub-basements of large buildings in which boilers and engines are located, and the means which have been adopted in some cases to afford relief to the engineers and firemen have generally proved entirely inadequate to produce measurably successful results.

The engine and fire-room ventilat-

ing plant in most instances consists simply of one of the several makes of exhaust fans, often too small for the work to be done, poked away in some corner chosen more with reference to convenience of installation than with a view to securing the best possible circulation of air. The impression, in fact, seems to be general that an exhaust fan will work well in whatever place it may be put; that it has a charm in itself which will cool the surrounding atmosphere, and that, at most, all that is necessary to make it successful is to provide it with an outlet and to revolve it at a convenient speed. The outcome of all this is that by far the larger number of engine and boiler rooms in large city buildings are about as uncomfortable places as one can well imagine, although, with a little forethought and rational consideration, they could be maintained at temperatures at which life would cease to be a burden to their inmates.

Where blowers are used to supply large quantities of air to different parts of a building, it has been found a good plan to have adjustable openings in the main air ducts where they traverse the engine room. From these openings a good supply of fresh air can be kept within reasonable limits. A rather unique case of engine and boiler-room ventilation provided for the removal of the heated air from a point near the ceiling, through a duct and blower, discharging into the ash pits under the boilers and thus forcing the fires. Forced draught for the boilers had been contemplated for some time in the establishment in question, and the plan just mentioned suggested itself as a convenient one of killing two birds with one stone, so to speak. The heated air removed from the engine room, it will be noticed, was not wasted, but was turned to good account in promoting combustion in the furnaces, which it did with much better effect than an equal quantity of cooler air would have secured.

Every place to be ventilated and cooled, however, has its special conditions which should govern the choice of plan, and what will serve excellently in one case will not always do the same in another; but with a reasonable amount of intelligence and judgment the problem of making the average engine and boiler room fairly comfortable ought to be easily and successfully solved.

The Physiological Effects of Working Under Compressed Air

From London "Engineering"

IN our issue of November 22, 1894, we gave a short description of the conclusions arrived at by M. Hersent, the eminent contractor, as to the precautions essential for the safety of workmen engaged in foundation-laying or tunnel-driving by means of the pneumatic plenum process. These conclusions were based, not only on M. Hersent's probably unrivalled experience with the process in question, but also on the results of numerous experiments made mainly on animals, but in some cases on men who had volunteered for the service.

The general result arrived at was, that when the men are working under high pressures it is most essential that the period of decompression should be very prolonged. When the pressure reached 50 pounds per square inch above the atmosphere, M. Hersent considered that the period of decompression should not be less than one hour; and that for a pressure of 75 pounds per square inch, three hours was not too great a time to allow for this. The highest pressure reached with the human subject in these experiments was 77 pounds per square inch, and the time taken in decompression was three hours.

These experiments of M. Hersent have recently been greatly extended by Messrs. Leonard Hill and M. Greenwood, and the results arrived

at by them are described in a paper just published in the Proceedings of the Royal Society. With praiseworthy pluck, the two gentlemen in question made the experiments on their own persons, each in turn being subjected to pressure in a large cylinder of 42.2 cubic feet capacity, put at their disposal by Messrs. Siebe, Gorman & Co. The highest pressure reached was 92 pounds above the atmosphere, corresponding to a head of about 212 feet of water. The period of compression was 54 minutes, and of decompression 2 hours, 17 minutes, or substantially more rapid than M. Hersent's experiments with lower pressures. The time spent under the highest pressure was, however, only a few minutes.

After coming out of the cylinder the subject felt some neuralgic pains in the forearms, but these did not last long, and were attributed mainly to the fact that he remained quiescent within the cylinder, which further experience proved to be a mistake, it being of great importance to keep every joint and muscle in motion, and to change position repeatedly, so as to keep the capillary circulation active in every part. When this precaution is taken, the rate of decompression can be increased. In order to relieve the pressure on the ear-drums, it is a common practice for workmen, whilst the pressure is changing, to open their Eustachian tubes by repeatedly swallowing the saliva. When suffering from catarrh, however, this plan does not always succeed; and accordingly the authors of the paper in question give another method, which is of certain efficacy, viz., to resort to a forced respiratoy effort, with the mouth shut and the nose held closed by the finger and thumb.

As the result of their experiments, they consider that work might be carried out safely in 210 feet of water, or possibly even 250 feet, the real limit being fixed by the fact that, when compressed, oxygen has a toxic effect. Thus, with an air compressed to 10 atmospheres,—equivalent to a head of about 350 feet of water,—animals are liable to be seized with convulsions within twenty minutes. In these experiments there was no confirmation of Dr. Snell's opinion that the presence of CO_2 in the respirated air has a particularly pernicious effect. A careful record was kept of the experiences of the subject undergoing experiment. At 16 pounds pressure the voice, it was noted, became metallic, and at 45 pounds pressure it became impossible to whistle. At the highest pressure reached articulation was difficult. There was no marked effect on the pulse. Further, after the nervousness due to the novelty of the conditions had worn off, there was no feeling of being under pressure. The sense of hearing appeared to be rather more acute than in the normal condition.

Leather Packing for Hydraulic Machinery

Arthur Falkenau Before the Franklin Institute

THE material to be used for packing is an important consideration. Where *U* or cup leathers are used, a close-grained flexible leather is desirable; of course, such leathers should not be taken except from the middle of the back of the animal. Leather treated with paraffin has given good results. There is no doubt that the method of preparation of the leather is an important factor in its imperviousness to water, and I have within recent years tried the Vim leather, which has given better results than any I had heretofore used. The manufacturers of the Vim leather claim that their peculiar process of tanning preserves the fibre and brings the fibres into closer contact. The process of tannage is one of oxidation by the use of a mineral, and for this reason the leather is not affected by oxide of iron, as are oak and hemlock-tanned leather.

For light pressures the leather is furnished without any filler, but for high pressure the leather is filled with a lubricant which primarily hardens the leather and renders it more impervious. It is claimed that owing to the process of tanning the Vim leather will absorb 45 per cent. of lubricant, as compared with 15 per cent. absorbed by oak-tanned leather. Furthermore, in moulding the leather no water is used, the leather being heated and thus sufficiently softened. The leather is not affected by hot water.

The blame for the failure of leathers, however, is frequently not chargeable to the material, but to the construction of the metal against which the leather rests. The *U* leather should, as far as possible, be backed by the metal over its curved portion, and should have either a metallic ring or hemp or other material inserted between the flaps. Furthermore, the surface over which the leather runs should be as smooth as possible.

Where leathers are used in valves in such a way that they cross ports, the construction should be such as to avoid blowing the leather out into the ports. I desire, however, to confine myself to the question of the kind and quality of the material to be used, and only call attention to these points of construction which, if neglected, may cause damage which should not be charged to the material.

In choosing the material for pumps used in removing fluids, such as mine pumps, ammonia pumps, etc., the question of chemical action on material is of great importance. In many of the mines in the anthracite coal regions the water is so permeated by sulphuric acid that cast iron cannot be used with any satisfaction. For several years I had preserved a specimen, which I had broken from a pump that had been in use about four years. The metal had been three-fourths of an inch thick. This was no longer cast iron, as the iron had been removed and only the graphite remained, and I could write with it as with a pencil.

Accidents in Power House Operations

H. Gilliam, in "The Electric Journal"

WE often hear of accidents that occur to the operators or apparatus in central stations. We are naturally more or less interested in knowing the cause or reason for these accidents. Investigation has shown that about 90 per cent of the accidents are caused by carelessness on the part of the operator or an assistant. Many ingenious devices have been designed to overcome carelessness on the part of operators, such as interlocks, telltales, and so forth.

It is the intention of the designing engineer to make power house apparatus as fool-proof as possible. Yet with as many safeguards as can be thought of, operators sooner or later become careless and accidents are generally the result, often causing severe strains to be thrown on apparatus, which sometimes lead to serious trouble.

In a certain power house the generators were connected to waterwheels, and in order to bring the generators to a stop it was the custom of the operator to short-circuit the terminals by means of a piece of cable after the water valves had been closed. This was done because the valves leaked enough to keep the water-wheels turning, but after being brought to a stop the leakage pressure was not enough to start them. The operator in this instance, through carelessness or forgetfulness, short-circuited a unit that was running at full voltage, and which was "cut in" on the bus bars. This unhappily resulted in the loss of the attendant's life as well as causing a considerable amount of damage to the electrical apparatus throughout the station.

There have also been a number of

cases in which trouble has resulted because the operator took some one's word that things were all right. This is a bad policy, and, if possible, everything should be checked over when any undertaking is in hand. When new apparatus is installed and is about to be started, those who have been assisting in the work will often state positively that all connections have been properly made. In many cases this has proven to be incorrect, and the result in some instances has been loss of time and suspension of service altogether with a severe strain on the apparatus.

Lack of technical knowledge has been a considerable drawback to many operators. Operators who have started in as oilers and have then been promoted to electrical attendants have been taught and have also learned by observation that by closing certain switches they could obtain certain results. As long as everything runs smoothly such men are very satisfactory attendants. But if something out of the usual takes place, they are, in most cases, helpless, and often cause additional trouble by mistakes they make while attempting to correct trouble.

There was one case in which the installation of some 250 KW., 60-cycle generators direct-connected to water-wheels was left to a man who claimed that he was well versed in this class of work. The machines were stored in the power house and subjected to more or less moisture. After being erected and started up, they could apparently be raised to only half voltage. A load was thrown on, however, and an attempt made to raise the voltage by speeding up the water-wheel. Then the insulation broke down between phases, resulting in the burning out of one-third of the winding.

The second machine was put through the same operation, and the instrument transformer burned out. This put an end to the experiments until the company manufacturing the apparatus could be communicated with. Investigation showed that the transformer voltmeter was connected up for the wrong ratio and the voltmeter was reading only one-half of the true voltage of the generator.

An amusing incident, which will illustrate the lack of knowledge on the part of an operator, and also give an idea of the class of men sometimes found handling electrical apparatus, occurred a short time ago. Several sub-stations containing oil-cooled transformers were installed in connection with a high-tension transmission line. One of the operators who had just been placed in charge of one of these sub-stations called up the erecting engineer and requested that he come at once to the sub-station and remove some frogs that had gotten into the transformers. Upon being asked how he knew there were frogs in the transformers, he innocently replied that anybody who knew anything at all could tell by the bubbles coming to the surface of the oil.

Such are the men to whose tender mercies power house apparatus is sometimes entrusted. But it is through carelessness rather than ignorance that troubles usually come. Intelligent care and common sense are the elements most needed in the handling of electrical machinery.

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SEE PAGE 383

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THE MANUFACTURE OF HIGH EXPLOSIVES

By W. H. Booth

FIG. 1.—A GENERAL VIEW OF THE COTTON POWDER COMPANY'S FACTORY AT FAVERSHAM. THE SMALL BUILDINGS ARE SCATTERED OVER A LARGE AREA. CONCENTRATION IS DANGEROUS

HIGH explosives, properly so-called, are those which will not explode except under special conditions. Ordinary black powder gives out its explosive property if ignited by a match or a spark. An explosion results because black powder is an intimate mechanical mixture of certain combustibles which burn with great rapidity and produce enormous pressures. But to obtain full effect from high explosives a detonator must be used, and the rapidity of explosion of such explosives is very much greater than that of gunpowder.

The basis of all high explosives is a chemical combination of certain nitrogenous substances. Nitrogen is an inert element, and, therefore, does not maintain a firm grip of the substances with which it is united, and such substances are said to be unstable. In the production of high explosives, the object is to produce a substance which, while reasonably stable under certain ordinary conditions, can be put into a condition of such excessive instability that it will decompose instantaneously. This instantaneous decomposition is explosion, and it is brought about with high explosives by means of a small detonator charge that is exploded in the middle of the charge of high explosives, and thereby gives such a

FIG. 2.—A GUN COTTON PRESS FOR TONITE CARTRIDGES. BUILT BY THE WEST HYDRAULIC ENGINEERING CO., LONDON

shock to the chemical molecular structure of the high explosive that the latent instability is invoked and explosion ensues.

A detonator for this purpose usually consists of a shell containing a compound known as fulminate of mercury with which is sometimes mixed a chlorate, and a detonator must be of such size and power as to be capable of bringing about this condition of molecular instability throughout the whole of the charge to be fired, otherwise a portion of the charge may not be destroyed and may remain a subsequent danger in a mine or elsewhere.

A safe and characteristic high explosive of the propulsive order is the cordite which is used in firearms of all sizes. Cordite consists of gun cotton, nitro-glycerine, and mineral jelly, suitably incorporated by aid of a solvent, acetone, which is dried out of the mixture, and leaves finished cordite as a horny, tough substance, resembling celluloid in appearance.

Naturally, in the production of an

explosive the dangerous processes must be minimized, and cleanliness, accuracy, and great care are required.

The nitro-glycerine used in cordite is a substance made by acting upon glycerine with nitric acid. Nitro-glycerine, termed "N.G." technically, is a dangerous liquid, but it can be made safe by certain admixture of other materials. Thus, dynamite is merely Kieselguhr, or diatomaceous earth, calcined and clean, which has been allowed to absorb a quantity of N.G. The quantity absorbed must always be less than the capillarity of the cellular diatoms enables them easily to retain without drip or overflow. Kieselguhr, fully charged with N.G., so that the liquid leaks out of the compound, is as dangerous as the unabsorbed liquid, because, when fully charged, there is no capacity for innocuous compression, and the full danger of an incompressible, unstable liquid may be developed by the most trivial cause.

In cordite, though solidity has been attained, the dangerous instability has been so far overcome that only by ignition can it again be brought into action. We may thus follow the manufacture of this article as one of the safest and best known propellant explosives, for cordite is used only as an ammunition.

The first process in a complete factory is the preparation of the raw materials, the principal of which is nitric acid. Nitric acid, the prime agent in effecting the nitration of hydrocarbons and carbohydrates to form explosive compounds, is made by heating nitrate of sodium (Chili saltpetre) with sulphuric acid in an iron retort. The reaction which takes place is,—

$$\underbrace{NaNO_3}_{\text{Nitrate of Sodium}} + \underbrace{H_2SO_4}_{\text{Sulphuric Acid}} = \underbrace{HNO_3}_{\text{Nitric Acid}} + \underbrace{NaHSO_4}_{\text{Bisulphate of Sodium}}$$

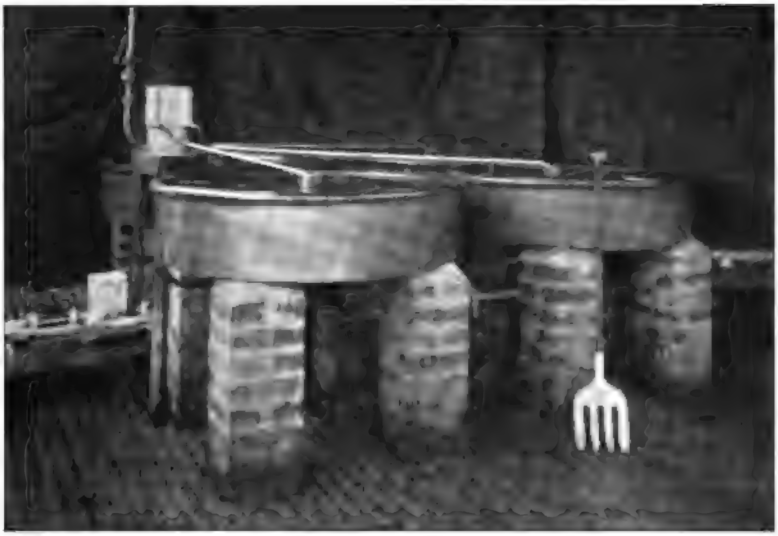

FIG. 3.—PLANT FOR DISPLACEMENT SYSTEM OF NITRATING COTTON

Nitric acid is given off as vapour, and is suitably condensed in large earthenware globular vessels arranged in series. The acid which condenses in these to a bright lemon-coloured fuming liquid, is drawn off, and is then mixed to the specific gravity

FIG. 4.—A MACHINE FOR PRESSING WET GUN COTTON INTO SLABS FOR DRYING

desired; in the manufacture of explosives the specific gravity ranges from 1.4 to 1.51.

The bisulphate of sodium remaining molten in the retort is run into iron pans, where it solidifies on cooling. This bisulphate has a value in the preparation of ammonia salts for manurial purposes. Sulphuric acid is purchased as concentrated oil of vitriol from the regular manufacturers, and is stored in large iron tanks, whence it is forced to where it is required by means of compressed air.

Nitro-cellulose varies in constitution according to the objects for which it is required. It is made in the form of dinitro-cellulose (commonly known as soluble nitro-cellulose or collodion cotton), tri-nitro-cellulose (commonly known as guncotton), and other variations, the greater degree of nitration corresponding with a more energetic action, the lower nitro-cottons being used for celluloid and similar products. According to the degree of nitrification required, the cotton is steeped in a mixture of sulphuric and nitric acids in varying proportions and strengths. The chemical formula for cellulose, of which cotton is one of the best examples, is $(C_6 H_{10} O_5)_x$ and it is obtained when cotton is treated with alkali for the removal of grease and oily matter, and afterwards bleached.

Trinitro-cellulose, or guncotton, is cellulose in which three of the atoms of hydrogen have been replaced by three molecules of NO_2. Thus $C_6 H_{10} O_5 + (H NO_3)_3 = C_6 H_7 (NO_2)_3 O_5 + 3H_2 O$, guncotton and water being produced. The water is taken up by the sulphuric acid, and, indeed, this is the object of mixing this acid with the nitric acid. The "waste" or used acid is gradually deprived of its nitric element and approximates to the condition of dilute sulphuric acid, and must be reconcentrated to make it fit for further use and receive continued additions of the nitric acid, or it may be used in place of sulphuric acid for purifying nitric acid.

Dry guncotton is very liable to explode on percussion. It can be detonated when wet, but will not take fire in a wet condition, and it is kept in a more or less damp condition as far as possible during the process of manufacture of explosives. If made with weak acid, the tendency is to produce the lower forms of nitro cottons, usually termed collodion cottons, and soluble in ether alcohol, which true guncotton is not, though commercial guncottons do contain some of the collodion cottons. True guncotton is considered to be by some the hexanitro-cellulose represented by doubling the formula above used to represent trinitro-cellulose, or $C_{12} H_{14}$, etc., but probably the formula $C_{24} H_{28} O_{20} (NO_2)_{12}$ (duodeca-nitrocellulose) most nearly represents its constitution.

Special tanks are provided in which the acids are mixed, and it may be here observed that the concentrated acids do not appreciably attack iron and lead, and that tanks made of either metal are employed to contain the acids. By the old process, cotton is dipped in batches of about a pound at a time into the acid mixture in iron or stoneware baths, which are water-cooled. It is lifted out and the surplus acid is gently squeezed out of it, and each dipping is then placed in a covered pot to soak and nitrate for twenty-four hours.

The cotton is good white waste from cotton factories, cleaned and bleached. It is usually preferred in this form because it hangs together sufficiently in the dipping. When soaking is complete, the batches are placed, one at a time, in a centrifugal extractor and the surplus acid is expelled. The guncotton is then at once drowned in water and conveyed to tanks in which it is washed and boiled for perhaps thirty-six hours to remove all acid. It is not considered washed until, by delicate tests, it is found to be free from every

FIG. 5.—INTERIOR OF A NITRATING HOUSE

trace of acid. In the latest system of nitration by displacement the acid is run into shallow pans of brown earthenware, Fig. 3, with perforated holding-down plates of the same material.

The requisite amount of cotton is steeped in the acid and left for two or three hours to nitrate, and a thin layer of water is run over the acid as a shield against the air. When nitration is complete, the acid is run out and water is gently run in above it, so that, as the acid runs out, it is followed down by the water. This is found to greatly diminish the further washing required, for the acid is displaced from the fibre by the water which follows dow ards after it.

When suffic ..y washed, the nitrated cotton is placed for several hours in a paper-pulp There it is passed continuously a and under the beater knives until it is in a condition of complete division exactly like paper pulp. The pulp is then pumped into other vessels and again washed and boiled, passed through a labyrinth to enable any heavy particles to drop out of the pulp, and finally it is dried down to about 28 per cent. of moisture in a centrifugal extractor lined with cloth. The guncotton is next triturated under edge runners, and is then fit for pressing or for the admixture of other ingredients.

If required for tonite, the cotton powder, as it now is, is mixed in nearly equal quantities with nitrate of barium, $Ba(NO_3)_2$, and the mixture is thoroughly incorporated under edge runners, and is ready to mould into cartridges for blasting purposes. This moulding is done by a special press, very similar in its action to a fuel briquette press, having a rotary table and a pressing plunger, as shown in Fig. 2.

If wanted for cordite, however, the guncotton, still containing from 20

to 30 per cent. of water, is taken to a press room and pressed lightly into large bricks by a press shown in Fig. 4, the pressing being done upwards against a heavy block which is made to slide out by a rack and pinion movement, thus enabling the blocks to be filled in and the pressed bricks to be raised by a second movement of the ram to the level for removal. These bricks are taken to the stoves, where they are laid on a long shelf, and exposed to a flow of air heated to about 100 degrees F. by steam pipes. The air is supplied by fans driven by a small engine to each stove, and the waste steam passes through the air heating pipes.

It may here be mentioned that an explosive works is scattered in the form of small shed buildings over a large area of grass land, as shown in Fig. 1. The usual manufacturing and organization economies are not possible, for concentration is dangerous. There are miles of steam pipes that cannot be avoided, but they are covered thickly with non-conducting composition and sheet-iron lagging, so as to protect them as much as possible against radiation losses.

When the guncotton is dry in the stove, the latter is allowed to cool, and the guncotton blocks are collected in india-rubber bags. Each stove contains a pair of long, parallel shelves with a passage between, and a lead-lined floor, lead floors being largely employed as being free from risk of gritty friction, as well as being waterproof and air-tight.

As a further precaution, no person must enter any of the so-called danger buildings, except he has his feet cased in large, leather, nail-free overshoes, or in felt shoes. At each door there is a vertical board sill, technically called a barrier, a few inches high, which must not be crossed except the feet are thus protected.

To the guncotton weighing room, the floor of which is kept wet, the bags of guncotton are now conveyed; the attendants wear india-rubber shoes with a copper rivet in the heel; this makes electrical contact with the lead floor, thus earthing the man and preventing the sparking which might occur from the generation of frictional electricity. In this room each bag of guncotton is made up to a fixed weight, and it is then ready to serve as an absorbent of nitro-glycerine, for which purpose it is carried to the nitro-glycerine in order to avoid carriage of this more dangerous article to the cotton. This nitro-glycerine is made in a distant house, Fig. 5, and its manufacture is the most dangerous operation in an explosives works.

The mixed acids,—nitric and sulphuric,—are brought to this department by a horse-drawn bogey tank from the acid-mixing tanks, and the bogey is discharged by air pressure to an overhead tank, whence the acid gravitates to the lead nitrators. Glycerine comes in drums from the soap works, where it is a by-product, and is pure, so far as the purposes of nitro-glycerine manufacture require it to be. It also is forced by air to gravity tanks. These have celluloid gauge "glasses," which will not fracture, to show the level of the fluid in the tank.

Outside the house is a large compressed air reservoir, supplied with air from the general system of compressed air pipes, and of such capacity that should a failure of the air compressors take place, this reservoir will suffice to complete the working of any charge in progress.

The converter vessel or nitrator is made of thick lead, solidly burned together. Burned into the bottom are coils of air pipes, perforated to admit air, for in all these dangerous processes stirring is required, and air is the most easy and frictionless means of agitating a liquid. In the converter there are water coils of lead pipe, and these are kept apart, coil from coil, by blocks of solid lead burned to the pipes so that there is nothing loose about the nitrator and there is no crevice or

FIG. 6.—INTERIOR OF THE WASHING HOUSE OF A NITRO-GLYCERINE PLANT

cranny into which liquid can enter and be trapped, so as to invite the risk of a blow.

Into this carefully fitted nitrator the requisite charge of acids is first run, cold water circulating through the pipes of the cooling coils. Into the cold acid the glycerine is sprayed by an air inspirator, which divides up the stream of glycerine into fine particles. Meantime, air rises from the pipes in the converter bottom, and the temperature is carefully watched. As a safety precaution, the whole room is built above a deep tank of cold water, and in case of emergency a single movement of a lever will discharge the contents of the nitrator into this large tank, the same single movement also producing a copious air agitation in the tank. By these means a charge which may betray symptoms of going wrong, such as would be indicated by a rise of temperature, is promptly drowned in the huge cold tank. The upper limit of temperature allowable is 77 degrees F.

When the charge in the nitrator is complete (in about thirty to forty minutes) waste acid from a previous charge is run in at the bottom of the nitrator, and displaces the now formed nitro-glycerine upwards, and this overflows by way of an outlet from the narrow top of the nitrator. This top chamber is a closed compartment with a glass window in the narrow overflow face. The nitro-glycerine containing a large colume of water, runs over into a first washing vessel, called a "forewash," seen between the two converter vessels in Fig. 5, the flow being stopped when the waste acid has risen to the sight window. In the first wash tank the liquid is washed by water agitated by a copious supply of air to free it from acid. The water is skimmed off by an india-rubber skimming pipe and dish after any particles of air-borne nitro-glycerine have been made to sink by a water spray which drives off the air. The liquid is then run into a second vessel containing a large volume of water, seen in front between the two stairways, and it washed again, and then it is run by gravity through gutters to the final wash-house, shown in Fig. 6.

In this the nitro-glycerine, which is a heavy, oily liquid, which one would imagine to be already quite clear of acid, is washed with alkaline water, with softened warm water and softened cold water, all waste water being run off through a labyrinth, which is a lead trough with a slop-

ing bottom divided into several compartments by cross walls rising from the bottom, while alternate hanging walls barely reach the bottom. The water passes under and over the edges of these divisions, and throws down any nitro-glycerine which it may be carrying off. This runs to the lower end of the trough by way of a small hole at the base of each division wall, and is drawn off and put back into the washing tank.

Glycerine, which is denoted by the formula $C_3 H_5 (OH)_3$, is a waste product of the manufacture of soap, and is the result of treating oil with caustic alkali, or by treating oil or fats with high-pressure steam. When treated with nitric acid, the three atoms of hydrogen are replaced by the three molecules of NO_2, exactly as in the formation of guncotton. The reaction is

$$C_3 H_5(OH)_3 + (HNO_3)_3 = C_3 H_5(NO_2)_3 O_3 + 3H_2O.$$

Again water is formed and combines with the sulphuric portion of the acid mixture, and the result is a "waste" acid in which some of the nitric acid has been replaced by water, and the waste must, therefore, be denitrated and concentrated free from water before it can be again used.

Nitro-glycerine is very heavy, its specific gravity being 1.6 at 59 degrees F., whereas glycerine, untreated, has a specific gravity of only 1.26 to 1.265. Like its congener, trinitro-cellulose, it is apt to explode on percussion, and requires the most careful treatment. Hence, the avoidance of loose parts or of crevices whereby the liquid might be trapped between opposed surfaces and exploded by the shock. It is in order to reduce handling and movement to a minimum that the nitro-glycerine does not leave the finishing house except when absorbed by cotton or other absorbents, which are brought to the nitro-glycerine for this purpose rather than that this should be unnecessarily moved about. To take out all possible nitro-glycerine, the mud which settles in the tank is run with the waste water into a pond at some distance, and at brief intervals a cartridge is fired in the bottom of that pond in order to blow up and

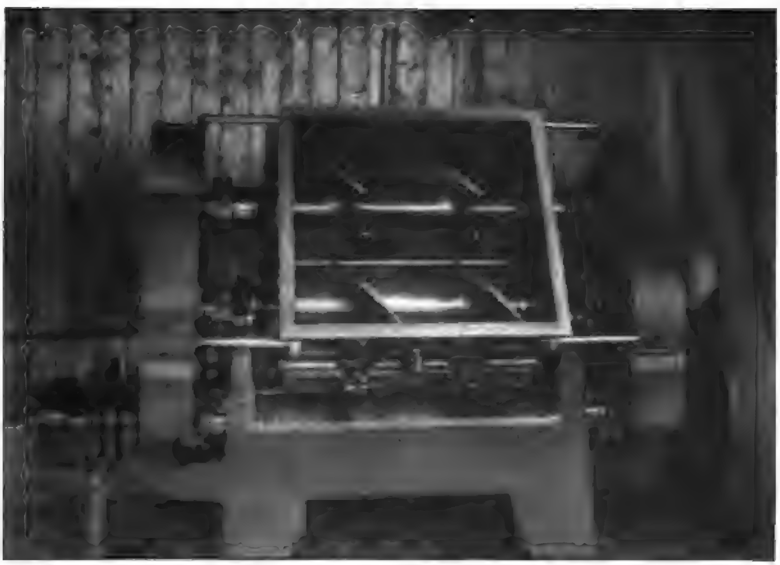

FIG. 7.—A CORDITE INCORPORATING MACHINE

destroy any vestiges of nitro-glycerine which may gradually accumulate there.

In the final washing house, Fig. 6, there is a special weighing machine, seen at the left. It would be unsafe to employ loose metal weights, and the counterpoise of this apparatus therefore is a copper tank with celluloid gauge glass marked at various heights, which represent various weights of water. The tank is filled up to one of these marks with water, as required for the mixture in hand, and nitro-glycerine is then run by an india-rubber pipe from the store tank into the opposite scale pan vessel to balance the water weight.

The blocks of nitrated cotton which we have seen transferred into bags in the cooled stoves are brought to the weighing house and receive the weighed charge of nitro-glycerine, which is promptly absorbed by the cotton and becomes safe to handle. The saturated cotton is carried, still in its bag, into a mixing room, where the bags are placed in lead containers, and opened, and their contents mixed by hand and transferred to a sieve box alongside and rubbed through the sieve into another india-rubber bag and carried away into the incorporating house.

The mixture, if for cordite *MK.* I, now consists of about 58 of guncotton and 37 of nitro-glycerine; if for cordite *M.D*, of about 65 guncotton and 30 of nitro-glycerine. It is placed in machines called incorporators, Fig. 7, which are simply a variety of dough mixers. To the mixture a solvent is added to the amount of 20 per 100 parts of *MK*I. paste and 42.5 parts for *M.D.* This solvent is acetone, a material produced by the dry distillation of acetate of lime, a product made from lime acted on by pyroligneous acid. Acetone is a volatile liquid which ultimately dries out of the finished cordite, and is used only to form the mixture into dough. Kneading proceeds for three and one-half hours, when 5 per cent. of mineral jelly is added, and incorporation proceeds for a second period of three and one-half hours. The dough now only needs pressing and drying to form cordite.

Since the constant supply of cold water is so important an item, there is a special central pump house at the works of the Cotton Powder Company, of Faversham, where the writer saw these various processes in operation. In this pump house there is an artesian well, 350 feet deep, whence water from the chalk is drawn up at a temperature of about 55 degrees F. for the cooling process.

There is a water-softening plant at another part of the works, and there are tanks in the central pump house for alkaline water, and for warm and cold pure or soft washing water, and from each tank there are branches to each of three final washing houses where the nitro-glycerine is finally purified and filtered through salt, which, being unaffected by nitro-glycerine, sucks out of it the last of its moisture, thus serving both as a filter and as a dryer. All waste washing water goes to a large tank in a further house, and is run through a labyrinth, to separate any possible nitro-glycerine that may still remain before the water is finally discharged to the waste pond.

Acetone, the solvent, has a specific gravity of 0.8, and does not enter into the composition of cordite, but is removed during drying. Chemically, it has no effect, but by its solvent action it brings the guncotton and nitro-glycerine into a homogeneous mass. Whereas alcohol has the composition C_2H_5OH, acetone is $(CH_3)_2CO$. It boils at 133 degrees F., and is expensive. The mineral jelly which is added to the cordite mixture and serves to lubricate the gun when fired, is chiefly a hydrocarbon of the paraffin series, though it contains also olefines.

It has no chemical influence on the cordite during manufacture, and, as stated, is added only at the middle

of the period of incorporation, which forms the last of the manufacturing processes.

It now remains to put the cordite into shape and dry it. The name cordite indicates its shape, for the material is used in the forms of fine threads, cords or rods, or even tubes, according to the size of the gun in which it is to be fired. The thickness of the cords and their length are determined by the dimensions of the barrel and the nature of the ballistics required. Thus, in a pistol, the cordite is in the form of a fine thread of about 0.01 inch diameter when dry, up to perhaps 0.55 inch for a large gun.

To make these cords, the finished paste is loaded into cylinders, Fig. 8, and pressed into them by a plunger with slow movement. These cylinders are of various sizes, according to the size of cordite to be made out of them. They are fitted with a cap which carries a die of one or more holes to which the mixture gains access through plates of gauze, which eliminate any small lumps of undissolved cotton or possible grit. The loaded cylinders are placed in presses, the smaller sizes of which, Fig. 9, are worked by worm gear-driven nut and screw, and the larger ones, Fig. 10, by hydraulic pressure.

The press plunger enters the cylinder and drives out the paste in the form of a thread, which has sufficient strength to hold together. The smaller sizes are caught on a plate of brass hanging before the press, Fig. 9. whence they are drawn and wound upon reels of light, perforated zinc, visible in the foreground, and on these reels the substance is dried, and becomes a strong hornlike cord.

The larger presses, Fig. 10, force three or more cords at once, which, however, cannot be wound upon reels. As they emerge from the die of the press cylinder the thick cords are carried away by a moving belt, seen in the right foreground of Fig. 10, on which, at equal intervals, there are upstanding knife edges, upon which the cords lie. The belt travels under a lightly spring-loaded gun metal roller, which presses the cords down upon these upstanding knives, and the cut rods, as they travel forward, are lifted off by boys and laid straight in wooden trays, on which they are cut to exact length and are removed as soon as possible to drying houses. The cutting and heels are reincorporated, so that there is no loss of material.

In order to avoid excessive pressure, such as would occur should the orifice of a fine die become choked by any accidental particle, the smaller presses are so arranged that the cylinder is carried below upon a level, weighted or hydraulically supported, table, so arranged that if the maximum allowable pressure is exceeded, the support yields and throws off the driving belt by means of a system of levers.

The completion of the stroke of the press plunger also serves to throw the belt across to the reversing pulley and to raise the plunger and allow another paste-loaded cylinder to be placed in the press.

This precaution is not necessary for larger cordite, for no obstacle remaining could choke the large die perforations. The larger cordite is taken off the machine in straight rods, and so dried, because it would not be practicable to use it in the curved form acquired by drying on a drum, for, when dried, it would maintain the curved shape too persistently.

The most tedious process is the drying-out of the solvent acetone. If the drying is done quickly, the surface of the cords is hardened, and the solvent cannot escape from the interior. Large cordite may thus require as many as 1600 hours in which completely to dry. This drying is effected in steam-heated stoves, which are not freely ventilated, and the drying of the exterior surface must proceed only as quickly as the interior will give up its solvent to the more outward portions. It is for

this reason, among others, that a large store of cordite is necessary to meet possible demands, because cordite is not stuff that can be made in a day or in a week, and any hurry in drying would cause the rods to

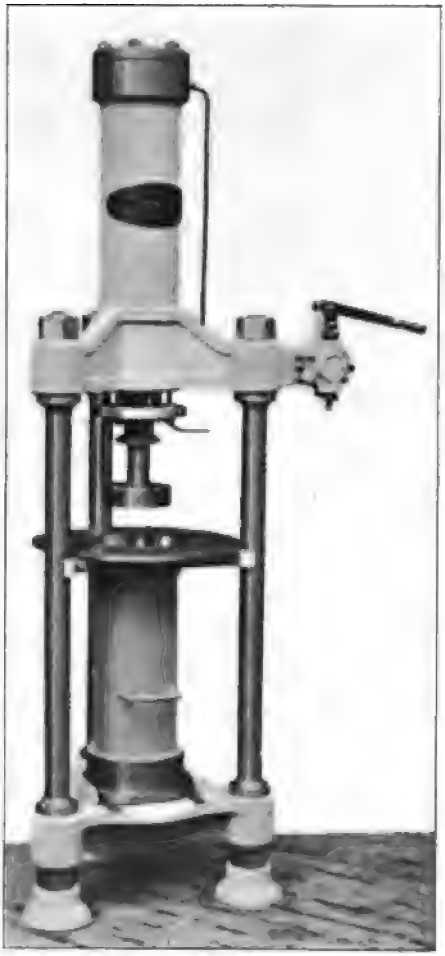

FIG. 8.—PRESS FOR FILLING CORDITE INTO CHARGING CYLINDERS OF CANNON-CORDITE PRESS

split and alter their rate of burning and spoil their ballistic properties.

The ballistics of a propellant depend upon the rate of burning and upon the weight of charge, the relative bulk of the charge and capacity of the chamber of the gun. If, with the same weight of charge, there were more cords of a smaller diameter, the burning would be more rapid, the gun would be exposed to greater stress, the pressure gases would lose more heat to the gun, and the muzzle velocity of the shot would be changed. The points sought by artillerists are that the charge should be completely burned, that the initial pressure shall not be excessive, and that the pressure shall be well maintained. The chamber capacity, other things being equal, determines the pressure generated.

The muzzle velocity of the shot depends upon the pressure exerted on the base of the shot, and the length of time during which that pressure is maintained. Thus, let us suppose a shot to weigh one-third of a ton, and that the pressure on its base is 1500 tons, then the acceleration effect would be $1500 \div \frac{1}{3} = 4500$ times that of gravity. The shot would gain, roughly, a velocity of 144,000 feet, or 32×4500 per second, during one second of the application of the force named, and it would, therefore, travel 72,000 feet in the time of one second. Now the distance travelled being as the square of the time, a gun 30 feet long would be traversed in the xth part of one second, or $l = 72{,}000\ t^2$, whence the time is found to be about $0.02 =$ 1-50 of a second, where l is the length of the gun traverse.

Since acceleration varies with the time duration of application of the moving force, the acceleration in 0.02 second would be $144{,}000 \times 0.02 = 2880$ feet per second, and this would be the muzzle velocity in a 30-foot gun under the stated conditions with the pressure acting steadily throughout the full length of the barrel.

Very brief fractions of a second of time have to be dealt with, and the burning of the charge must be very rapid. Still, brief as are the times, there is a time element involved, and it is important to pay due attention to it if the small allowance of muzzle velocity variation

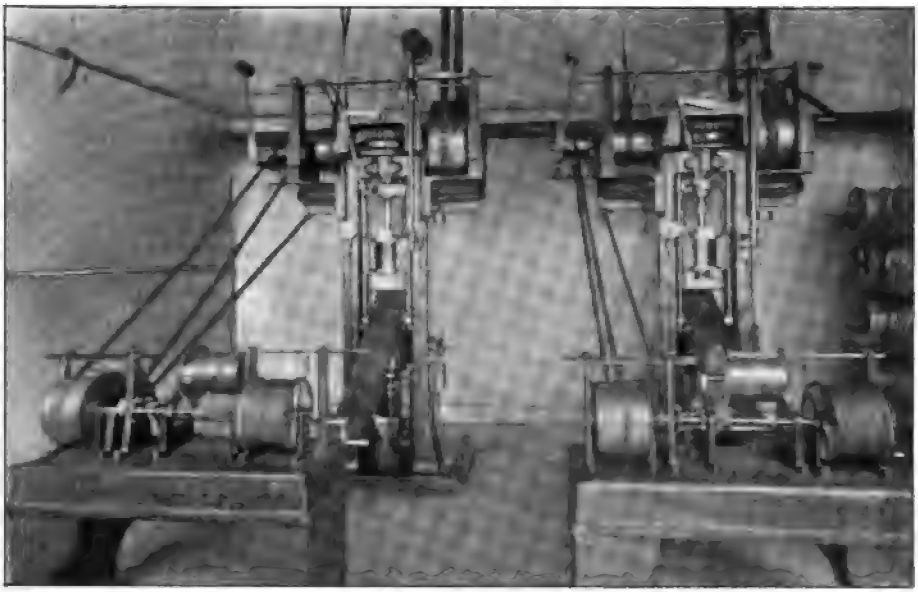

FIG. 9.—RIFLE CORDITE PRESSES

of only 10 foot-seconds is not to be exceeded. To secure this uniform action the cordite must be blended so as to eliminate the accidental variations of the cords, the weight of which is determined per 100 inches and the diameter of which varies with the weight per unit length.

For the finer sizes explosive the charge consists of sixty lengths of cord made up by first combining into a simple untwisted strand ten of the reels as made from the press. The ten reels are placed in a frame, as seen in Fig. 11, and the cord is led to a single reel. Six of these ten-strand reels are then similarly blended into a strand of sixty cords, which is chopped off into lengths to form the charge of a pistol, a rifle, or a shot-gun.

For the larger sizes or rods the dried lengths are gauged according to their diameter, or length weight, and a case of finished cannon cordite consists of so many sticks of size *x*, so many of size *y*, and so many of size *z*, etc., selected so that the ballistics of the whole shall be equivalent to the ballistics of the standard blend. Thus, where sticks are to measure 0.500 inch diameter, they may measure 0.499 inch, 0.500 inch, 0.501 inch, and so on, and they must be assorted to give correct ballistics.

Blending is thus seen to be a very important item in the manufacture of cordite.

Having completed the manufacture of the explosive, the question of economy comes in. We have seen how the nitrating acid mixture loses its properties and becomes diluted. It is necessary to concentrate this waste acid for re-use or sale. For this purpose the acid is allowed to drip down a tower composed of a peculiar "volvic" stone containing broken earthenware. A current of steam drives off the remaining nitric acid into earthenware condensers in the form of vapour, and the sulphuric acid which falls to the bottom of the tower is then passed down a second rectangular tower of "volvic" stone, through which it descends from tray to tray.

Upward through this tower are drawn the hot gaseous products of a coke furnace, the gases being drawn

FIG. 10.—A CANNON CORDITE PRESS

under a succession of water seals formed by the dipping of trays of the "volvic" stone into the acid in the next lower tray. A steam ejector performs the drawing action, and the hot gases carry off the water from the acid. The final concentrated acid is passed through a cooling coil, and then is fit for use again, and is returned to the supply tanks. This system of concentration, known as Kessler's, is much more efficient than the old system of pan concentration. The coke employed must be good, in order not to introduce undesirable impurity into the acid. The acid used to nitrate cotton may thus be dealt with, but it is generally used in the nitric acid retorts to produce fresh nitric acid.

Other high explosives require similar care and cleanliness in manufacture. A few only need be named which can all be made in the same sheds by the use of the same mixing machinery. Cordite alone has its separate plant. Thus, blasting gelatine is simply a solution of soluble nitro-cotton in nitro-glycerine. Nitro-cotton is a lower nitrated form of cellulose. It is mixed with nitro-glycerine in copper vessels and allowed to dissolve and gelatinize in a warm place for some hours.

Gelignite consists of a blasting gelatine, as above, incorporated with nitrate of potash ($K N O_3$) and wood meal, which is finely powdered pine wood. This wood meal adds carbon to the mixture. The blasting gelatine is first placed in the pan of the incorporator, the other ingredients being added while the machine is in motion. The incorporating machine, Fig. 12, consists of a series of star-shaped stirrers on vertical spindles working in a movable jacketed pan. Guides are provided to keep the pan in the correct position. The stirrers cannot touch one another as they revolve, nor can they touch the sides of the pan, which, when ready to incorporate, is lifted up to the mixing level and lowered again by machinery when incorporation is complete. These plastic explosives are put up in paper wrappers. Those which are deliquescent, such as the am-

FIG. 11.—A MACHINE FOR REELING SMALL-ARMS CORDITE

monium powders, are wrapped and then dipped in melted paraffine wax, to exclude moisture.

Tonite No. 1, as already stated, is a mixture of guncotton and barium nitrate. Tonite No. 2 contains, in addition, tri-nitro toluol $C_8 H_2 (NO_2)_3 C H_3$. Toluol $(C_6 H_5 CH_3)$ is one of the hydrocarbons obtained by distillation of crude benzol. While it resembles benzol, it is less dangerous, and is converted into nitrotoluol by means of fuming nitric acid. It is used in place of dinitro benzol $C_6 H_4 (NO_2)_2$, because this latter product is unhealthy to work with. Being waterproof, the blasting gelatine and gelignite are thought by some to be useful for subaqueous work, but they are dangerous for this purpose, since, if unexploded, they may be afterwards accidentally exploded by a drill or by dredger friction. Hence tonite is largely used for this work, and is used in tin cases and is safe, for it contains no nitroglycerine.

Certain high explosives are manufactured for use in coal mines. These explosives have to pass very severe tests at the Home Office Testing Station at Woolwich before they can be placed on the list of "Permitted Explosives," and these tests have been devised to ensure the non-ignition or non-explosion of gases in fiery mines by any of the explosives on the "Permitted List." Geloxite, rexite, normanite, and Faversham powder are the "Permitted Explosives" which the writer saw in process of manufacture.

Lyddite, of which so much was heard during the Boer war, is a nitrate compound into which picric acid enters, this being a tri-nitro phenol, or $C_6 H_2 (NO_2)_3 OH$, formed by acting on phenol or (carbolic acid) with nitric acid.

It is scarcely necessary to say that in so delicate an article as an explosive the science of chemistry is most necessary, and the laboratory is the most important department of an explosives factory. Everything must be tested, both the raw materials and the finished product. Thus, nitroglycerine is tested for stability by

heating it in a test tube by means of a water bath. If, for instance, any oxide of nitrogen is given off, this will be shown by the discolouration of a bit of iodide of starch test paper moistened by glycerine and suspended in the test tube above the nitro-glycerine being tested. This paper should not be discoloured until after the test has been in progress for eighteen minutes at a temperature of 180 degrees F.

To determine the amount of nitro-glycerine in any explosive, the sample contained in a filter thimble is subjected to extraction by ether.

FIG. 12—AN INCORPORATING MACHINE FOR BLASTING GELATINE

Guncotton and other forms of nitro-cellulose are tested for nitrogen value by ascertaining their content of nitrite oxide, a weighed sample being treated with sulphuric acid over mercury in a nitrometer which measures the volume of the oxide given off. Throughout the whole process of manufacture the material in progress is tested for condition, quality, density, etc. Thus the acids must be tested for concentration, the glycerine must be tested, the cotton must be known to be clean, and even the thermometers must be watched, for in the nitro-glycerine converter a temperature must not be allowed above 77 degrees F., nor under any circumstances above 86 degrees F., which demands prompt drowning

The class of explosives known as fulminates are not employed in large quantity, but are used to detonate the high explosives or to disturb their molecular stability and induce explosion. Fulminates are put up in little copper capsules which, in electric fuse denotators, are enclosed and

FIG. 13.—A MACHINE FOR SLICING CORDITE FOR BLANK CHARGES. BUILT BY THE WEST HYDRAULIC ENGINEERING CO., LONDON

sealed by a wooden plug, through which enter two electric wires, the terminals of which are bridged by fine iridio-platinum wire around which is wrapped a little nitro fibrous cotton, which, in turn, fires the fulminate lower down the short tube.

A usual fulminate is that made from mercury, and is prepared by dissolving that metal in nitric acid and adding alcohol to the solution. It explodes at 360 degrees F., but is not explosive when water-soaked. The fulminates of silver, gold, and platinum are even more sensitive than that of mercury, and are unsafe to employ. Mercuric fulminates possess the quality of a fair stability, and yet detonate strongly when fired. It is important that detonators

should act well, or they may fail to explode a charge. Hence they need careful proportioning, according to the nature of the explosives. They must not, however, be carried with other explosives.

Blasting cartridges are packed in five-pound cardboard cases, and these are placed in wooden cases for shipment. Cordite for the government is packed in painted cases of the customary yellow colour of ammunition wagons. The cases are lined with waterproof paper, and conveyed by barge to Woolwich.

A barge for government cordite must be smoothly lined with wood, all iron knees or cramps are cased in lead, and a coarse kind of flannel blanket is laid on the flat, boarded floor.

The operations and arrangements thus very briefly sketched are those followed at the works of the Cotton Powder Company, Ltd., at Faversham. The works lie about four miles out of the town on the banks of the Swale, which is a tidal channel separating the Isle of Sheppy from the mainland of Kent County.

As already stated, the stirring of the dangerous liquids is performed by compressed air, which is sent around in pipes at a fifty-pound gauge pressure from a central station. Steam also has to be sent around to the various sheds for engine driving and stove warming, and steam economy is not possible with so great a length of pipe, however well clothed and protected. The boilers are worked with a fan draught, and this enables the main flue to the chimney to be built over a long trough of water, which serves to catch most of the heavy dust which is deflected out of the gases by deflectors and caught by the water surface. The pit extends outside the flue, the walls of which dip below the water. As mud accumulates, it can be raked out through the water. Dust is thus kept out of the materials in course of manufacture. High mounds of earth are placed between dangerous buildings to minimize the effect of explosion.

A curious effect of explosion upon distant buildings is that these are burst by internal pressure, the effect of an explosion at a distance being apparently to project the atmosphere vertically, producing a partial vacuum around so that the air inside a vacuum-surrounded shed simply bursts it open. For this reason the contents of the sheds are quite separated from the walls, and a shed may thus burst without injuring its contained apparatus.

Finally, it may be said that the manufacture of explosives is surrounded by such care and hedged about by rules and inspection that the death rate is by no means high. If a man is making steel and he makes a mistake by letting the steel be fouled, by say phosphorus, this steel may slip by inspection and may cause deaths by failures of railroad axles, by bursting of boilers, or the fracture of a rail. If, when this phosphorus was passing into the steel, the converter furnace were to burst and kill everyone about it, much would be heard about the accident, but there would be no after tale of rotten bridges and axles and scores of lost lives. Now, in making nitro-glycerine a similar error or culpable carelessness that produces bad steel declares itself in its own way by prompt explosion, and all trouble is stopped. Two men are rubbed out absolutely, but there is no further mischief to be recorded. The machines used in the manufacture of explosives are of slow movement, and are operated by hydraulic pressure. Those illustrated are made by the West Hydraulic Engineering Company, of London and of Luton.

The tonite cartridge press, Fig. 2, is simply a refined briquetting machine suitably modified to fit the different class of material with which it deals. Another machine, Fig. 4, compresses guncotton into blocks for drying. There are the reeling machines, and there is a machine for

slicing cordite rods into thin wafers for blank cartridges. This machine, Fig. 13, will cut 180,000 wafers per minute from a series of rods projecting through the face of a steel block.

Other machines are the reels for pistol and rifle cordite, and the presses for filling the cylinders from which the cordite is extruded through dies. In the brief space of a single article it has been possible only to skim over the surface and touch lightly on the salient features of the production of a high explosive. The writer is indebted to Mr. Arnold, the manager, and to the staff of the Cotton Powder Company for their kind assistance in the preparation of this article and their explanation of the various processes of manufacture.

ALCOHOL AND THE FUTURE OF THE POWER PROBLEM

By Elihu Thomson

Recent legislation in the United States, by which denaturized alcohol may henceforth be produced free from taxation, has at once helped to make alcohol an important factor in the fuel problem. Already the lighter oils, for internal combustion engine use, largely through the enormously increased consumption in automobiles and motor boats, have given evidence of coming scarcity and advancing price, and for these alone, not counting multifarious other fuel uses, alcohol will be an excellent and readily available substitute.—The Editor.

MODERN civilization is based upon the use of power,—upon engines of one type or another. In large measure the power is derived from fuel. In cooler climates our comfort in winter is to a great extent a question of cheap fuel, while the various processes, such as the smelting and working of metals, the making of glass, the baking of porcelain, and so on, are factors in the gradual exhaustion of available combustibles,—coal, peat, oil, gas and wood of the forests.

Practically our whole problem of over-sea transportation is a fuel problem. Our land transportation is the same to an almost equal extent. Occasionally a water-power is available, to furnish, through the agency of electricity, the energy required for a railway, but the coal or oil-consuming locomotive will, doubtless, hold its own for a long time, except in the most densely populated districts. Where electric locomotives or trains are used, the power station will still depend in most cases upon fuel.

The population of the world and the expenditure of fuel for heat, light, and power steadily rises. A time must come when, under the continued and increasing drain, the cost of fuel will be increased, and the available supply diminished, until the advancing cost due to scarcity and distance of haul will at last check the consumption. Our heating in winter is a peculiarly wasteful process. Our buildings leak heat all over. We consume enormous amounts of fuel to maintain temperature conditions which are worse than wasteful. We oftentimes maintain temperatures indoors in winter in excess of those we seek in summer when we flee the city.

In our heating and ventilating systems we assume that when we discharge the air we must discharge it hot, and take in fresh, cold air, giving it fresh heat from fresh fuel. This is all wrong. What we will be compelled to do when our fuel cost is increased will be to transfer the heat from the escaping warm air to the cold supply by a system of regeneration, supplemented by a construction of buildings which will cut off heat leakage and waste from that cause. In this way the air leaving a building will pass through a structure like a regenerator and will there deliver its heat to the incoming fresh air. Such regenerators can work at quite high efficiencies. The regenerating system will also be applied more extensively than at present to furnace processes, and waste furnace heat will be conserved for various uses.

But when all this and more is done the fuel question will still exist. The crisis, though delayed, must assuredly come. It avails little to

say that in China there is coal to supply the world for hundreds, if not thousands, of years. We may not control that supply; the cost of transporting it may make its use almost prohibitive.

Our fuel supply is the result of solar radiation in the geological past. Energy of the sun was stored in the earth millions of years ago. Our water-powers are the result of solar radiation in the present; the water evaporated from the tropic seas is deposited on the cooler heights of land, and we incidentally use a small fraction of the energy play involved.

Solar radiation must continue to be the source of our power and heat. The growing plant can, by cultivation in the favoured districts, be encouraged to assimilate, so to speak, the solar energy. We already have the timber of the forests, the brush wood, the straw of the wheat field.

The ideal fuel, however, is, undoubtedly, liquid fuel of a nature to be readily vapourized. If the liquid be of a limpid, non-viscous character, the difficulties found in pipe-line transportation with the thick fuel oils will not stand in the way of such transportation and distribution.

Fortunately, we have in ethyl alcohol an ideal fuel,—colourless, limpid, of moderate boiling point, about 50 degrees below that of water, non-freezing, burning without smoke, mixing with water in all proportions, and, therefore, its flame extinguished by water, cleanly, drying off completely when spilled, not attacking rubber gaskets or packings, and non-corrosive for metal tanks and holders.

The fact that its flame is bluish, or so-called non-luminous, means that the flame is almost devoid of free carbon particles, with their intense heat-radiating power, a fact of considerable importance. When gasoline or heavy oils are burning, the flame, loaded with free carbon or soot, radiates heat to such a degree that it is not possible to approach near the conflagration, and combustible surroundings are readily fired by pure radiation of heat.

The production of alcohol on a large scale is very simple, and the raw materials already exist in considerable variety. All saccharine or starchy growths are available. Saccharine wastes are now largely used in Cuba for alcohol production. At present it is said that the low grades of molasses can be delivered at American coast cities at about three cents per gallon. About three gallons of this crude product will be required to produce a gallon of refined spirit, or 90 per cent. alcohol, and the cost of production may be estimated at from three to four cents, making the cost of the alcohol per gallon about twelve cents.

This alcohol will, in a properly organized engine, equal, volume for volume, gasoline now sold at a much higher price, in producing power. Even in the immediate future, then, it is evident that alcohol has a large field of usefulness. The farmer need not depend on wood, coal, or oil for his power. His agricultural wastes will furnish it. His fields need only receive the sunshine, and be given sufficient water, and thence any crop yielding starch or sugar, however unmarketable otherwise, may be made the source of power, light, and heat.

The use of alcohol as a fuel, and as a source of power, will grow gradually. It would be idle to look for any sudden revolution in methods. It would, in fact, be very undesirable. Revolutions are destructive. Evolution, a slower process, is constructive. Gradually a system of production and distribution must be evolved, even for present needs.

But when we extend our vision into the far future, we can only speak of possibilities or probabilities. There is always a possibility of new discoveries modifying conditions to such an extent that our best present judgment may be in error. But assuming that increasing scarcity and

cost of mineral fuels will gradually stimulate the selection and use of substitutes, it seems reasonable to predict that the one substitute which possesses the most desirable qualities is ethyl alcohol. The amount that can be produced is practically unlimited.

A very important fact distinguishing alcohol production by agriculture from the production and shipment out of the land of food products, meat, etc., or even wood, is that in the former the land is not impoverished, as the mineral and nitrogenous matters can be returned to it, while in the food and wood carried away the richness of the land is passing away, too.

Alcohol contains only carbon, hydrogen, and oxygen, all of which come from the air itself. The transformation is begun in the carbonic acid and water of the air reaching the growing plant under the influence of sunshine, and completed in the fermenting vat and the still under human direction. Vigorous plant growth is a cooling process; solar energy is rendered latent or potential. It would even be possible to calculate from the fuel value of any growth or crop the proportion of the solar energy so stored up. Fermentation renders the energy stored more available, and distillation finally yields a concentrated product.

It is not unreasonable to expect that, in large engines of the internal combustion type when highly developed, we may attain efficiencies of 30 to 40 per cent. This means that of the heat units potential in the fuel, and liberated when it is burned with the oxygen of the air, about one-third may be converted into available power. It may even be that future invention will carry this proportion up to about one-half. With alcohol at a cost of ten cents a gallon,—a price even now realized in Cuba,—the cost of the fuel per kilowatt-hour would be about one cent and a quarter on an assumed efficiency of 33 per cent. in the engine.

It is not to be imagined that where coal or oil can be obtained at anything like the present costs there is at present any possibility of their replacement. Neither is it likely that water-power, developed under favourable conditions, can ever have as a rival artificially produced fuel.

But inasmuch as the fuel cost is only a relatively small fraction of the total cost of operation of a great system of distribution, such as that of an electric lighting plant or railway, it is evident that, considering the great convenience and adaptability of the alcohol vapour internal combustion engine, a wide field may open for its application, as the cost of the fuel alone is a relatively unimportant item. Certain it is, that for isolated small powers the alcohol motor can soon be used with convenience and economy in America, following the recent legislation there, removing the onerous tax.

As to the more distant future period, we need have no misgiving. We are assured that mankind, by the introduction of methods of economizing heat, and by artificially produced liquid fuel, will be able to maintain those activities demanding heat and power until "the sun himself grows dim with age, and nature sinks in years."

SMOKELESS FUEL FOR CITIES

ITS RELATION TO THE MODERN BY-PRODUCT COKE OVEN

By C. G. Atwater

IN every city a regular and sufficient supply of fuel is a necessity. In those localities not favoured with abundant and accessible water power, it is the only source of power, heat, and light. In the large majority of cities the fuel supply is practically limited to coal, the exceptions being those having an ample supply of crude oil or natural gas. If these last-mentioned sources were the rule, or if the supply were in general on the increase, they could be regarded as ideal; but unfortunately this is not the case. Coal must still be considered as the main factor in fuel supply, and in the methods of employing it must be sought the betterment of existing conditions.

It is the purpose of this article to examine the relation of the by-product coke-oven process as a method of treating coal for use in cities, and to discuss the grounds on which its present limited introduction is expected to undergo wide extension.

The principal use of coke at present is in the smelting of iron ore in the blast furnace. The melting of pig-iron in foundry cupolas absorbs a considerable quantity, though but a small proportion of the total output, and some is used by the smelters. These industries may be said to be based on the use of coke, as no other fuel will serve the purpose at as low cost. The production of coke in the United States for the year 1904 is given in "Mineral Resources" as 23,621,000 net tons. Of this quantity possibly 3,000,000 tons were used in foundries, and 1,000,000 tons for various minor industrial, railway, and domestic purposes.

There was also a production of about 2,000,000 net tons of gas house coke, made in coal gas retorts, practically all of which was consumed for the last-mentioned purposes, or in making carburetted water gas. If we neglect the latter item, we may say that approximately 3,000,000 net tons of coke were used in the United States for minor domestic and industrial purposes. As it is with these figures that we are particularly concerned, the coke consumption for blast furnace, foundry, and smelting purposes will be eliminated, so far as possible, from figures quoted hereafter.

The chief advantages in the use of coke as a domestic and industrial fuel, it may be said at the outset, lie in its cleanly and absolutely smokeless character. These qualities it shares with anthracite coal, and on the appreciation of these advantages by the public at large rests, in great measure, the permanent solution of the smoke question. It does not seem probable that any form of artificial gas can be made cheaply enough by existing methods to entirely supplant solid fuel.

In order to show how small the total domestic and industrial coke consumption quoted above is, when compared with the amount of coal at present used for general purposes, and thus indicate the possible field for coke, Table I. has been prepared, giving the amount of anthracite and bituminous coal consumed in various cities of the United States, arranged in the order of their population.

TABLE I.—FUEL CONSUMPTION OF VARIOUS CITIES. NET TONS

City	Population	Anthracite Tons	Bituminous Tons	Total
New York..	4,014,000	9,000,000	3,500,000	12,500,000
Chicago....	2,020,000	1,403,154	6,842,043	8,245,197
St. Louis....	714,600	154,442	5,239,283	5,393,725
Boston	602,500	1,929,573	2,312,882	4,242,455
Cleveland ..	465,000	330,802	2,227,671	2,558,473
Cincinnati ..	425,000	21,800	3,466,836	3,488,636

The above figures are taken from the Chamber of Commerce reports of the several cities, and are subject to various local conditions which make them only approximately accurate. They may, however, be assumed as fairly representative.

It is probable that the figures for Boston include considerable coal received at Boston, but used in towns to which access may be had by water outside of Boston proper. About 224,000 net tons of coke made at the New England Gas & Coke Company's works, near Boston, and representing over 320,000 net tons of bituminous coal, are used in locomotives running out of Boston,—a purpose not strictly local. Considerable coke is also shipped to other towns of which no report is made by the Boston Chamber of Commerce. These considerations may account for the apparently large coal consumption per capita in Boston, as given later in Table III.

The gas consumption of the cities mentioned in Table I. is given in Table II.

These figures are taken from Brown's Directory of American Gas Companies and the current report of the Massachusetts Gas & Electric Light Commission. The consumption of natural gas in Cleveland is

TABLE II.—GAS CONSUMPTION OF VARIOUS CITIES.

City.	Population.	Annual Gas Consumption, Cubic Feet.
New York, (Manhattan & Bronx)..........	2,400,000	21,075,000,000
Chicago..............	2,020,000	12,008,000,000
St. Louis............	714,600	4,000,000,000
Boston..............	602,500	3,084,000,000
Cleveland...........	465,000	1,500,000,000
Cincinnati...........	425,000	2,000,000,000

not included in the above figures, which probably accounts for its relatively small proportions.

In order to make possible a comparison between the fuel consumption in the form of coal and that as gas, Table III. is given, showing the per capita consumption of coal and gas and of anthracite alone. Compared on the basis of actual heat units contained, one ton of anthracite coal is equal to about 45,000 cubic feet of gas. Such a comparison would not, however, truly represent the actual conditions of service, as practically no gas is used except where especial advantage is obtained by virtue of its more economical application, ease of regulation, and adaptability to intermittent use. A more proper ratio would be from 10,000 to 20,000 cubic feet as equivalent to a ton of coal. Even at this ratio, it may be easily seen from the table that the quantity of gas used is but a modicum of the total fuel requirement per inhabitant. Moreover, it may be fairly estimated that from 60 to 70 per cent. of this gas are used for illuminating purposes pure and simple, and are affected to some extent by the use of kerosene and other illuminants not locally derived from coal.

TABLE III.—FUEL CONSUMPTION PER CAPITA OF VARIOUS CITIES.

City.	Coal Consumed Total Net Tons.	Anthracite Alone Net Tons.	Gas Consumed Cubic Feet.
New York......	3.12	2.24	8800
Chicago........	4.00	0.7	5940
St. Louis.......	7.55	0.21	5600
Boston..........	6.70	3.18	5120
Cleveland	5.43	0.71	3230
Cincinnati......	8.20	0.051	5180
Average	5.83	....	5645

It is noticeable in Table III. that New York uses the least coal and the most gas. That is partly because of the congestion of population.

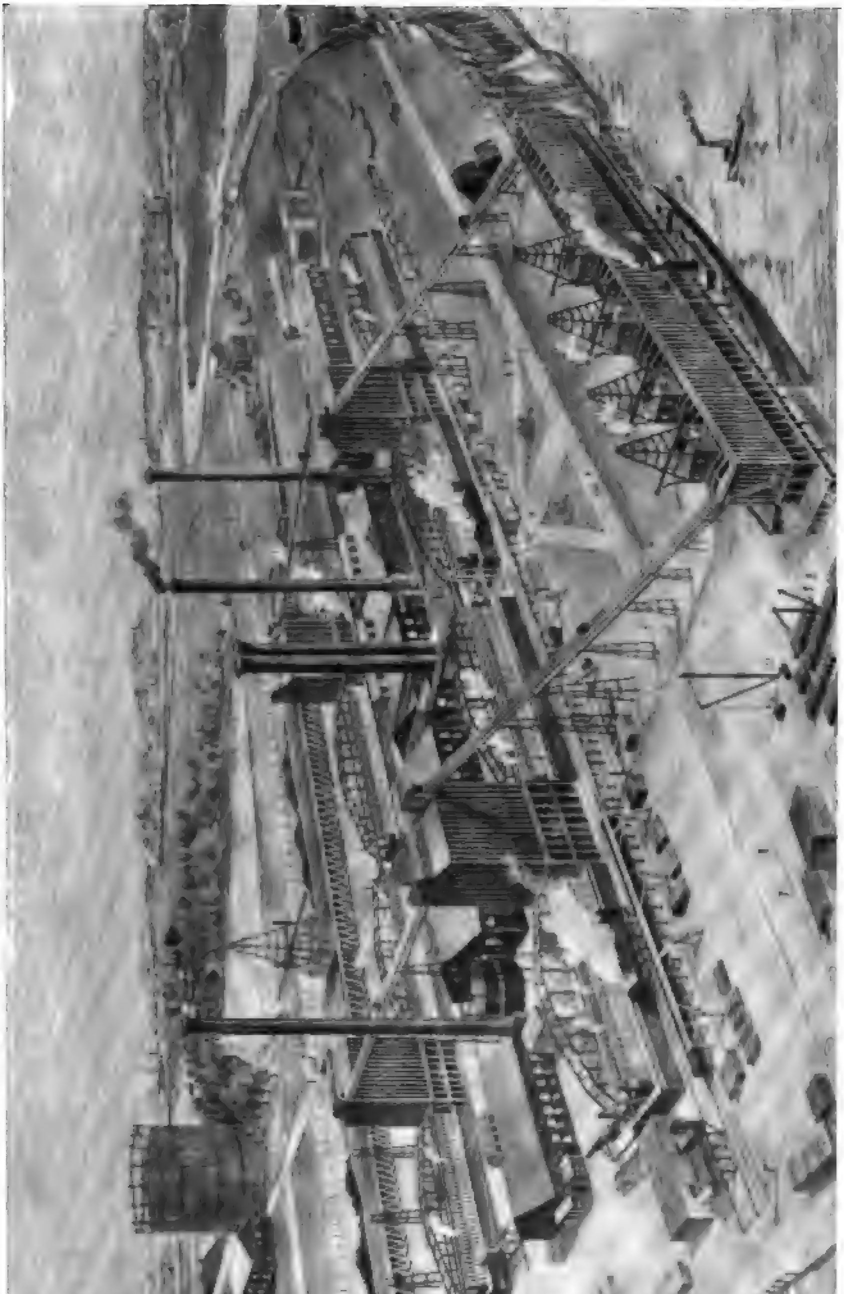

FIG. 1.—THE BY-PRODUCT COKE OVEN PLANT OF THE NEW ENGLAND GAS & COKE COMPANY AT EVERETT, MASS. THE EIGHT BATTERIES OF 50 OVENS EACH ARE ARRANGED IN A DOUBLE ROW. THIS PLANT WAS THE FIRST TO MAKE GENERAL USE OF ELECTRIC MOTORS IN THE OPERATIONS USUALLY PERFORMED BY HAND OR BY STEAM POWER, AMONG THESE INNOVATIONS BEING ELECTRICALLY OPERATED PUSHERS, COAL LARRIES, DOOR HOISTS, QUENCHING CARS AND VARIOUS SMALLER DEVICES

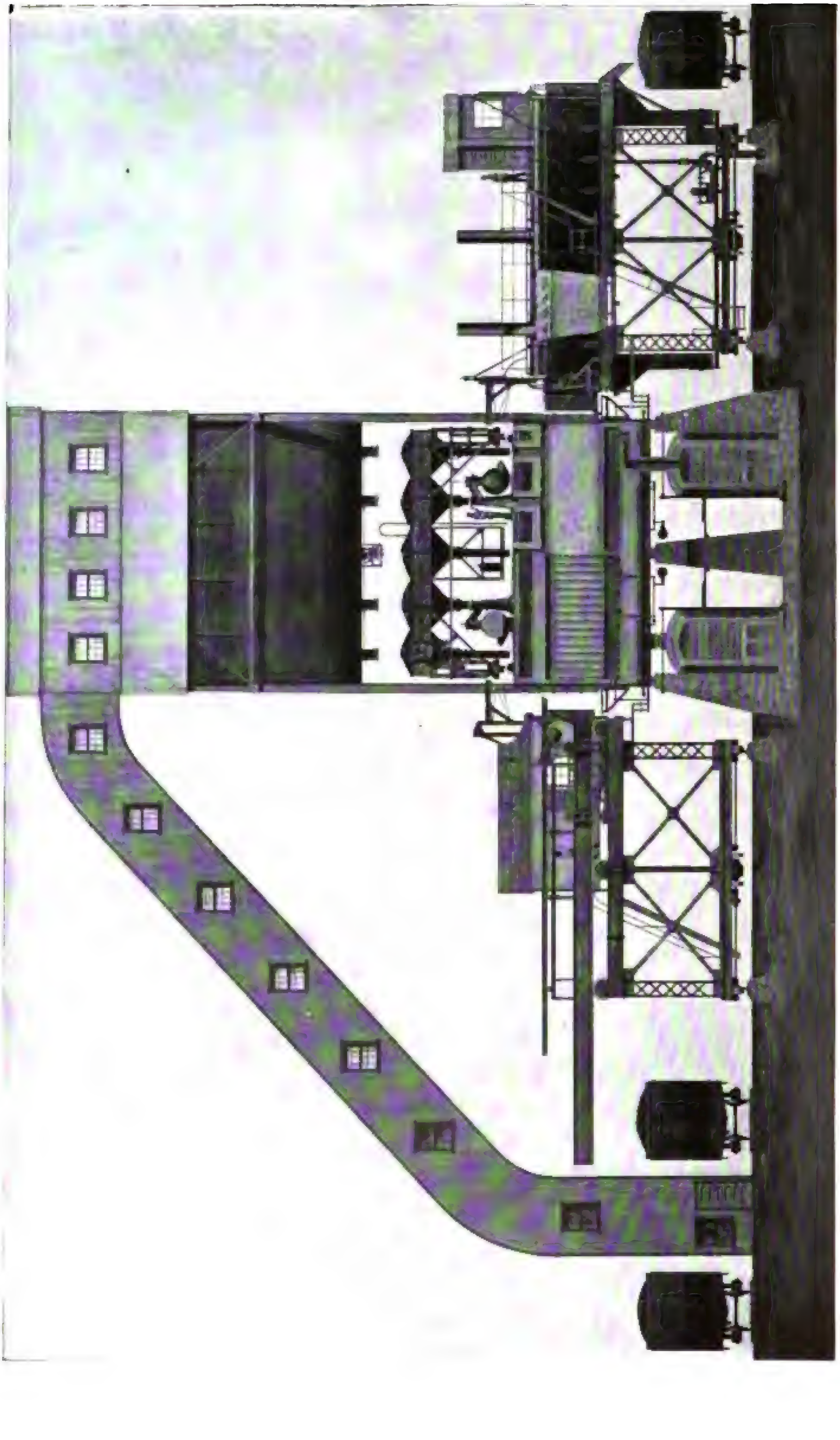

FIG. 2.—SECTION AND ELEVATION OF A BY-PRODUCT COKE OVEN AS INSTALLED BY THE UNITED COKE & GAS COMPANY, NEW YORK

which tends to increase the number of apartment houses and hotels, where many families are supplied with heat from a central plant, and where cooking is done by gas, and partly because the city is so pre-eminently a commercial one, the manufactures being largely in those lines requiring moderate amounts of fuel and power.

Chicago, next in size to New York, stands next to it both in total coal and in gas consumption. These figures tend to confirm the natural assumption that the increase of population in a given area decreases the requirements for coal and increases those for gas per inhabitant. In England, where there are 604 inhabitants per square mile, as against an average of 349 in Massachusetts, or 153 in New York State, the consumption of gas in cities is higher per inhabitant in many cases than in New York.

If, however, we set aside New York as being an extreme case among the cities of the United States, we may say that an average city would use 6 tons of coal and 5000 cubic feet of gas per inhabitant per year.

For the sake of convenience in discussing the subject, without referring to any particular city, let us assume a community of 500,000 people for which, on the above basis, the fuel supply would be 3,000,000 tons of coal and 2,500,000,000 cubic feet of gas per year. If the city in question were in the New England States, New York, Pennsylvania, or New Jersey, to which district, according to "Mineral Resources" for 1905, over 80 per cent. of the anthracite shipped are sent, it would be reasonable to expect that from 30 to 60 per cent. of the coal used would be anthracite. The consumption per inhabitant throughout this district, indeed, is estimated by the same authority as 2.42 net tons per capita, which agrees fairly well with the figures for New York and Boston in Table III.

If, however, the supposed city were more remote from the anthracite region, the proportion of bituminous coal would be very much greater. The figures for the other four cities in Table III. indicate the startling contrast. This soft coal, burned under prevailing conditions, would inevitably produce a large amount of smoke, and give rise to the undesirable conditions with which the residents in Western American cities are but too familiar.

There are, of course, many devices on the market for burning soft coal without smoke, but all of them require competent and skillful handling, in a greater or less degree. While they may give good results on plants of large capacity, on those of moderate or small size they have not always proved of lasting benefit. The low grade of labour employed has, so far, proved the great obstacle to the smokeless consumption of bituminous coal, and the necessary educational process is likely to be a long one. With anthracite or with coke, on the other hand, even ignorance and carelessness cannot produce smoke.

The gas, according to present practice, could be produced by one of three methods, (1) the carburetted water gas process; (2) the coal gas retort; and (3) the by-product coke oven. In the first case anthracite coal or coke is burned in a generator in alternating currents of steam and air, the gas produced by the dissociation of the steam and the accompanying combustion of the fuel being subsequently enriched by petroleum vapours. The product of this process is practically nothing but gas, the small residue of water-gas tar not being worth considering as a fuel factor, even were it so employed, which is not usually the case.

In the second case, the gas is made by the destructive distillation of bituminous coal in the gas retort. For the production of 2,500,000,000 cubic feet of gas per annum, about 250,000 tons of coal would be

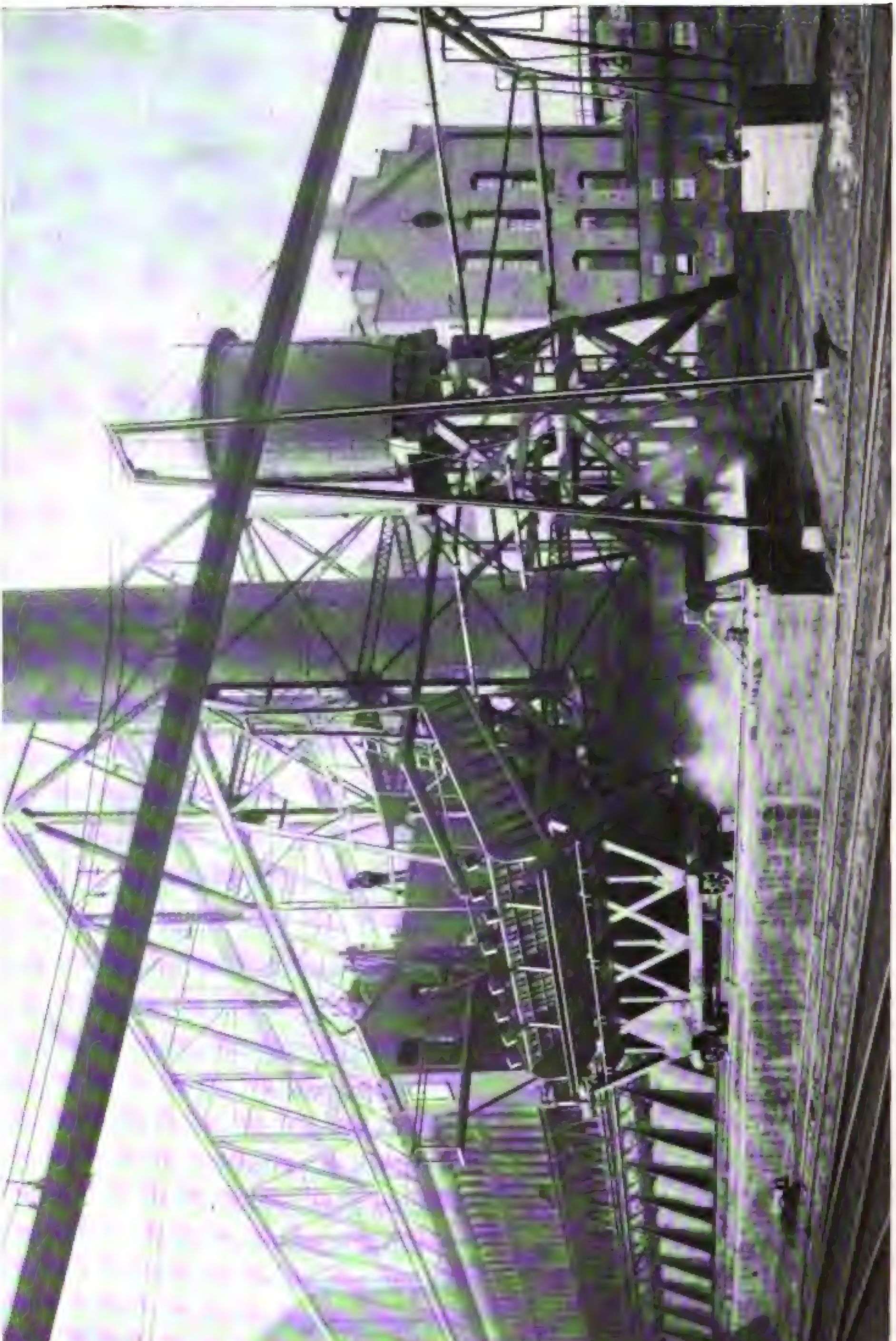

FIG. 3.—BY-PRODUCT COKE OVEN PLANT AT DULUTH, MINNESOTA. ONE OF THE INCLINED COKE-QUENCHING CARS IS HERE SHOWN

needed, from which there would be obtained about 125,000 tons of coke, after supplying fuel for heating the gas retorts. This coke can be disposed of for domestic and minor industrial purposes in the city itself, and is usually so absorbed, although for this purpose it is inferior to the harder coke made in the by-product oven.

In addition to this amount of coke there would be approximately 2,500,000 gallons of coal tar, which would be equivalent to 20,000 tons of coal or coke for fuel purposes, though not ordinarily so employed. There would then be a contribution of 145,000 net tons of coke, or its equivalent, to satisfy the solid fuel requirements before mentioned.

In the majority of cities, the gas supply is produced by a combination of these two methods, in which case the coke from the gas retorts is used for fuel in the water-gas generators and the residual solid fuel is less than when gas retorts alone are employed. When the only object in view is the economical production and distribution of artificial gas, without regard to the larger field of solid fuel supply, the combination of water gas and coal gas apparatus is regarded as the most desirable arrangement.

The reasons for this point of view lie primarily in the increasing cost of the oil used for carburetting the water gas, and in improved gas-retort construction and operating machinery, which have, generally speaking, reduced the operating cost of a continuously-run retort plant below that of a corresponding carburetted water gas plant. As the investment for the latter per unit of gas output is still the smaller, and as its flexibility in respect to capacity fits it particularly for service in seasons of temporarily increased demand, it may be considered good practice to cover the requirements for the summer output by a retort gas installation, and to rely on carburetted water gas for the increase in winter consumption.

The third way to obtain the gas for the city supply would be from the destructive distillation of bituminous coal in by-product coke ovens. The advantage of this process is that it treats the coal in ovens of large capacity, carbonizing per day approximately eight times as much coal in an oven as in a retort, and thirty times as much per charge. This scale of operations causes a great saving of labour and allows automatic machinery to be used throughout the process. The quality of coke produced is much superior to the gas retort product. It is harder and stronger, hence makes less dust and fine "breeze." It is also lower in volatile matter. These qualities make it very similar to anthracite coal, and fit it for domestic as well as for metallurgical use. For the latter purpose gas-retort coke cannot be considered.

To make the required 2,500,000,000 cubic feet of coke-oven gas, the destructive distillation of 555,000 net tons of coal would be necessary. This would yield 390,000 net tons of coke, as well as about 5,550,000 gallons of tar, equivalent to 44,400 net tons of coal or coke if used for fuel. There would be, then, a total contribution to the city fuel requirements, outside of the gas supply, of 434,000 net tons of coke, or its equivalent. As the annual requirements are 3,000,000 tons, and as it has been abundantly demonstrated that by-product coke, properly crushed and sized, is as convenient a fuel as anthracite coal, there is no reason, outside of the cost, to question that the output of by-product coke can be readily absorbed in each case by the local market. In order that the relation of the three processes may be clearly seen, their results are summarized in Table IV.

The results show that, for an equal amount of gas delivered, but from a proportionately larger amont of coal treated, the by-product coke oven supplies three times as much coke as its nearest competitor, the gas retort,

TABLE IV.—FUEL REQUIRED

Gas, cubic feet	2,500,000,000
Coal (or coke) net tons	3,000,000

FUEL SUPPLIED

	Carburetted Water Gas Process	Retort Coal Gas Process	By-product Coke Oven Process
Gas (1000 cu. ft.)	2,500,000	2,500,000	2,500,000
Coke, or coke equivalent, net tons	Negligible	145,000	434,000

although the coke supply is still far below the existing solid fuel consumption.

It should be stated here that because of the increase in winter consumption over that in summer, it is not economically advisable to rely on by-product coke ovens alone for the total gas supply, as has already been set forth in connection with the coal gas retort process. If we assume that 75 per cent. of the total gas made per year could be most economically made in the gas retort or by-product coke oven, the figures for the equivalent solid fuel supply would be 97,000 and 284,000 net tons, respectively. This does not alter the ratio of the two figures materially.

The amount of coke supplied under the assumed conditions is still far short of the demand for solid fuel. It may be expected, however, that the natural increase in the use of gas will cause the consumption of as much as 8000 or 10,000 cubic feet per year per inhabitant, as these figures have been already reached in New York, and in British cities. The practical doubling of the quantity of gas used will doubtless be attended by a decrease in the use of solid fuel. As the figures for New York show, the coal consumption is but little over half of that assumed. Therefore, the tendency of the demand for solid fuel, and its supply in the form of coke, under these circumstances, will be to approach each other rather than to recede.

In cities where the proportion of anthracite coal used equals or exceeds that of bituminous coal, the problem of introducing crushed coke as a substitute rests mainly on the ability to supply it at an attractive price. Its introduction in such instances, if made through proper channels, and with a well-organized campaign of publicity and instruction, has invariably resulted in the creation of reliable and increasing demand.

This has already been done to some extent in the cities of Boston, Mass.; Philadelphia, Pa.; Camden, N. J.; Washington, D. C.; Detroit, Mich.; Hamilton, Ohio; Cincinnati, Ohio; Milwaukee, Wis., and to a less extent in many other cities.

The plant of the New England Gas & Coke Company, at Everett, Mass., which supplies about 224,000 net tons of crushed and sized coke per year to Boston and vicinity, and as much more for use on locomotives, is shown in Fig. 1. This plant also supplies from five to six million cubic feet of illuminating gas per day for distribution in and around Boston.

Where the use of bituminous coal is general, and public spirit is so lax as to prefer the continuance of the smoke nuisance rather than pay the slight extra cost of a smokeless fuel, the introduction of coke for this purpose must await the awakening of public opinion. The approaching exhaustion of the anthracite coal supply, and the improbability of any decrease in its cost, which already prohibits its extensive use in the cities more remote from the anthracite fields, precludes the possibility of help from that source. Coke is, so far, the only practical substitute for anthracite, and it would seem that its use must inevitably increase to an enormous extent.

In order that a clearer idea may be afforded of the by-product oven and its construction, the following description is added to the foregoing discussion:—

Fig. 2 shows the latest type of the United-Otto by-product coke oven, together with the coal-handling machinery, coal bin, and the appliances for pushing the coke from the oven and quenching it. The coal is re-

ceived on railway cars, as indicated at the extreme left of the illustration, and is conveyed to the overhead bin, from which it is delivered to the electrically-driven charging larry shown on top of the oven itself, and is fed into the oven through separate spouts corresponding with openings in the oven roof.

After the coal charge has been levelled in the oven by an automatic device, the oven is closed and the distillation period begins, continuing usually for twenty-four hours. At the expiration of this time the oven doors are removed, and the coke is pushed out of the oven by the pusher ram, at the left hand of the illustration, into the quenching machine on the right hand, where it is cooled with water and then discharged into the railway cars alongside. The coke cars are then shifted to the crusher, where the coke is broken and sized by screens, or, if for metallurgical purposes, it may be used without further preparation.

The ovens are heated by a portion of the gas given off during the distillation period, which is burned in a system of vertical and horizontal flues contained in the oven wall and substructure, shown in the left hand portion of the oven section. Heated air for the combustion is supplied from the regenerators below, through which the outgoing gases and the air alternately pass.

The advantage in the use of regenerators in this connection lies not so much in the ability to obtain high temperatures, which, indeed, are attainable without their use when gas of such heat value (500 to 600 British heat units) is available, but in the heat economy obtained in gas consumed. The waste gases after passing the regenerators, are delivered to the draught stack with only sufficient heat to create a proper draught.

The gases distilled from the coal are led away through the two gas mains shown above the ovens. One of these serves for the earlier and richer gas, which is reserved for illuminating purposes, while the other main receives the later portion of the gas, which is lower in illuminating value, and is used for heating the ovens. Both qualities of gas are subjected to the usual process of cooling and condensation, and yield tar, ammonia, benzol, and other by-products. The rich gas fraction is subjected to the usual oxide purification for the removal of sulphur, and is a coal gas of high quality, having 650 to 725 British thermal units and an illuminating value of 16 to 18 candle-power, which may be increased by the transfer of benzol from the poor or fuel gas fraction.

The yield of surplus gas per net ton of coal charged depends to a large extent on the quality of the coal. With a coal mixture of from 30 to 32 per cent. of volatile matter, which would not be classed as a gas coal for retort use, a yield of over 4600 cubic feet per net ton is regularly maintained, the illuminating value being over 18 candle-power.

Another view, that of a plant in actual operation, is given in Fig. 3. This represents a general view of the ovens and accessory apparatus. The form of coke-quenching car is somewhat simpler than that shown in Fig. 2. This plant consists of 50 by-product ovens of the United-Otto type, and is in constant operation at the works of the Zenith Furnace Company, at Duluth, Minnesota, supplying metallurgical coke suitable for blast furnace or domestic use, and illuminating gas for the cities of Duluth and Superior.

NEW BUSINESS FOR ELECTRIC CENTRAL STATIONS

QUESTIONS FOR THE CENTRAL STATION MANAGER

By John Craig Hammond

Mr. Hammond's subjoined remarks are supplementary to what was said by him under the above head in the July number, making the fifth of the series of "Business Getting" articles. The questions here presented by him to the central station manager are, in his opinion, at the foundation of a central station's advertising and "new business" policy, and make what Mr. Hammond in his characteristic way might have termed new thinking points.—The Editor.

NEW business methods have been shrouded with so much mystery, so much guess work, that I hope to reveal a few of the secrets in this article. In discussing new business methods with a central station manager recently, he said:—"But our plant is in the midst of the hard-headed, slow-thinking Dutch of Pennsylvania. They don't like new ideas, they are satisfied with the old ways. The breezy methods would not do."

I did not agree with him. If a man is hard-headed he should be all the easier to convert to the advantages which a central station can supply.

Before advertising and new business methods are taken up, the central station manager must remember just one thing and keep that one thing in front of him,—he wants to sell more current at a profit. His business is just as much a commercial proposition as that of a dry-goods merchant who wants to sell dress goods.

The central station manager wants to sell current to every one who can be induced to use it to advantage,—don't forget advantage,—for that's important. Don't try to make a man use fifty 16-candle-power lamps when twenty-five will do the work just as well. It is as bad policy to overstock a consumer with current and extra light as it is for a hat manufacturer to sell a merchant twice the number of hats he can dispose of.

I am going to submit a list of questions,—questions that I have asked in the past. The answers to them might in some cases be nearly the same, but the methods of carrying out the work would not be the same, always. But the questions, I think, point out the foundation on which a central station manager must work. If I were called upon to advise a manager, no matter where he might be located, I would want replies to these questions before I could give him a sensible answer. I think every advertising agency should work from some such foundation. Here are the questions:—

What is the population of your city or town?

Do you own or control both gas plant and electric station?

If you do not own the gas plant, what methods does the gas company use to get new business? Does it advertise; does it do any city lighting; is it making an attempt to put in gas arcs?

What is the capacity of your station?

What are your rates? If you have a flat rate or rate for power, commercial, and residence, give different charges.

Do you give good service? Answer that question honestly; explain what your consumer thinks of you; state whether you get only a moderate number of complaints or if you get more than your share.

How many miles of wire have you? How many people can you serve who are along your lines to-

day and who are not consumers?

Do you expect to extend your poles soon? If so, will it be in residence districts, and how many new consumers do you estimate you will reach?

How many consumers have you to-day?

Have you a correct list of what they are using? Have you made up a card list of what your present consumers can be induced to add such as power, porch lights, fans, or electric heaters?

Have you a list of non-consumers? Do you keep a record of all removals?

Have you ever done any advertising? If so, give a detailed report of what kind, the cost, results. Did you "follow up" your advertising by personal solicitation?

How many newspapers have you in your district? Are they friendly to the company? If not, state what papers are friendly and those that are fighting you. If there is any local reason why you are being attacked by the newspapers, give the reason.

Have you been bothered with the question of municipal ownership?

Is your company in politics?

Is your office in business district? Can you use your windows for an office display? Do you use an electric sign yourself, or do you outline your office windows with lights?

What newspaper advertising have you been doing, and what are the rates for the different publications?

Have you every employed a solicitor? Who "goes" after new business to-day? Do you keep a record of new business being erected? How does your company stand with local architects and builders?

Have you a Chamber of Commerce or local organization for the physical improvement of your city or town? Do you take part in this work?

Do many merchants use electric signs, or light their windows at night?

How many isolated plants have you? What is the difference in their rates and your rates?

From the above questions, some idea can be obtained as to how a start must be made in laying out an advertising and new-business policy for a central station. There are more questions to the point, but the above indicate to some extent what is required.

Say a central station manager gave complete answers to all the above questions. In many cases more questions would have to be asked before the campaign could be started with any degree of common sense. If the central station manager happens to be a man with a "nose for advertising," he will add other information that will make the work of the advising expert easier.

In a previous article in this magazine, I insisted that the central station manager must do some thinking,—he should advertise and organize a new business department; but he must think out his problem, he must take into consideration his conditions, keeping in mind at all times that he is in business to sell current, and the only way he can sell more current is to go after more business.

I have not discussed the organization of the soliciting force. There is hardly a more important point to the policy of the company than their "new business" men. To outline a policy for solicitors is the work of many hours and days and weeks and months of thought and study. You must change with the wind, but don't let your men get off the one viewpoint, and that is, that they are representing the company in an effort to get acquainted with the public, to get more business, to get the friendship and loyal support of the consumer. I know there is a big field for the young man who wants to go ahead in the commercial side of a central station. Give him the proper training and he can find a position,—he can talk the most conservative manager into trying his methods.

Up to the present time, no one has

started a school of training by correspondence for central station men. What an opportunity for some one to find practically a virgin field. Henry L. Doherty is the only central station operator that I know who has such a school, and Mr. Doherty is not going into the correspondence educating business. And the students—that word is well used—who work for any of the stations operated or managed by Mr. Doherty, find a position in one of the score or more plants in which he is interested.

I had used a dash to guide the printer in knowing that my article had closed with the above sentence. But an objecting electrical expert says he is not satisfied with reading the above.

"Why, a central station man may answer all your questions and then you might tell him to do so and so and then leave him high and dry. Explain to them what they must do in such an such a case."

That, from a man who I was sure understood new business methods! But he doesn't. What will the man who is still deep in the dark say, is what bothers me. I cannot give the answer. I am trusting, hoping, however, that I may have given some new idea, some thought, some suggestion whereby the central station men can start to do his own thinking. He must do some of the thinking. It might be that in one city newspapers could do much of the work; again, only a limited amount.

Take this as a guiding line and you won't go so very far wrong. Mr. Central Station Manager, make up your mind that you must sell more current. If you have 10,000 people, and know every man, woman and child, don't let that stop you from advertising. Advertise with your next-door neighbor if you think mail advertising is the best way. But advertise after you have weighed the matter with care. Get the advice of some expert. It won't cost you much. Don't follow it just because it comes from an expert. Why not? Because you are following blindly the advice of some one, who may know, or who may be wrong in your case. Think for yourself; reason matters out in your own way, remembering once more that you want to sell more current at a profit. And the last thing to remember is,—What is the best way? Mail cards, billboards, to you?

Think that point over. Forget you are a central station man. Imagine yourself a merchant for the time being. What would strike you as the best points to make? Think along these lines and act and watch the results.

WIND POWER

By E. Lancaster Burne

TO obtain motive power at the least possible cost, is a question that so often arises that the windmill, the most economical of all prime movers, appears to deserve more attention than it receives. Wind, unlike water, is not limited to place or in quantity, but may be obtained almost everywhere, and is free to all. Furthermore, it entails no expense in itself. This cannot generally be said of water power, which usually involves the construction and maintenance of dams and conduits, to say nothing of the periodical cleaning, in some cases, of ponds.

The great drawback to wind power is, of course, its irregularity and uncertainty, and although a fall of water is subject at times to drought, flood, or frost, it will ever be superior to wind on this account,—when it can be obtained. In the absence or insufficiency of a waterfall, it may, therefore, be profitable to employ a windmill, if the work to be done admits of suspension during a calm or consists of the storage of energy for future use.

The advent of suction gas plants and the adoption of crude oil have so cheapened power production by internal combustion engines that it is scarcely worth while to depend upon wind power for work of the first nature, except in those districts where fuel is difficult to obtain. Far wider possibilities exist, however, for an accumulated energy system, such as the raising of water to reservoirs for supply purposes, the generation and storage of electricity for lighting or power, and possibly, to a limited extent, the compression of air into storage tanks.

Wind, it is almost unnecessary to observe, is due to the movements of the atmosphere in recovering a state

ONE OF TWO WINDMILLS SUPPLIED TO THE JOHANNESBURG MUNICIPALITY, SOUTH AFRICA, BY MESSRS. SAUNDERSON & CO., LTD., BEDFORD, ENGLAND

A WINDMILL DRIVING A "SCOOP WHEEL" WATER LIFT FOR LAND DRAINAGE. INSTALLED BY JOHN WALLIS TITT, WARMINSTER, ENGLAND

of equilibrium. The condition of unstable equilibrium is brought about by changes of temperature or humidity, which alter the density of the air in different places. If one portion of the atmosphere becomes heavier than another, it will, in accordance with the law of gravity, rush into the lighter or less dense area and so produce wind which will continue until equilibrium is restored. It follows therefore that, other things being equal, the denser the air, the greater its pressure, so that a cold winter wind will possess more power than a warm summer one, assuming the velocity and other conditions to be the same in both cases. For a like reason, winds at a high altitude are not so effective as those of the same velocity at sea level.

Owing presumably to the friction of the earth's surface, the velocity of the wind increases with the height above ground level; it has been computed by Mr. Thomas Stevenson that if the velocity at a height of 50 feet is 1.0, it will, at 25 feet, be nearly 0.9, but at 100 feet it will amount to 1.2. These results indicate the advantage to be derived from mounting windmills on high towers.

The most important consideration with regard to the wind in the present connection is its average velocity and duration. As these conditions are necessarily governed by the situation, it is possible only to generalise. In Great Britain the average rate throughout the year, at inland stations, may be taken as about 7½ miles an hour; but in some exposed situations, in the neighbourhood of the sea, it amounts to as much as 16¾ miles an hour. A speed of 10 miles an hour is generally attained during one-half to three-quarters of the year, according to locality, whilst a 16-mile wind may be expected, under favourable conditions, for about one-third of the year. Unfortunately, the windy periods do not occur at regular intervals, and calms of several days must be provided for.

WINDMILL PUMP AND WATER TANK FOR FARM SERVICE. INSTALLED BY MESSRS P. & W. MACLELLAN, LTD., GLASGOW

A WINDMILL ERECTED FOR THE LONDON & SOUTH WESTERN RAILWAY BY JOHN WALLIS TITT, WARMINSTER

If the velocity of the wind is doubled, its pressure is quadrupled; thus, a 20-mile wind is eight times as powerful as a 10-mile breeze,—the product of the speed and pressure increasing as the cube of the velocity. Theoretically, the power of a windmill follows the same law; practically, however, it is modified by two factors.

With light breezes the power absorbed in overcoming the friction of the mill will bear such a large proportion to the kinetic energy of the wind that the actual power available for doing work will be very small; hence, at the lower end of the scale the working capacity will increase very rapidly with every increment of wind speed.

On the other hand, with high wind velocities the speed of the windmill cannot be permitted to increase in the same ratio, so that a large proportion of the wind force must be run to waste. From these considerations it will be apparent that to obtain the greatest effect from the wind's varying impulse, the work to be done by the mill should augment with an increase of speed in the same proportion as the wind pressure varies with the velocity.

When circumstances permit, the raising of water by centrifugal pumps would fulfill these conditions, as the discharge of a pump of this type increases with the square of the velocity. Dynamos for charging accumulators, so constructed as to generate current at a constant voltage under wide speed fluctuation, afford another example. In milling or similar work, where an attendant is present, the load can, to a great extent, be adjusted to the strength of the wind prevailing; if this is less than 10 miles an hour, it is generally regarded as of little use, but if over 20, sail has usually to be shortened or other regulation made to prevent any further increase in rotative speed

The case is somewhat different with pumping mills of the annular disc type. It appears that a well-constructed wind-engine will just commence to run with a breeze of 3 to 4 miles an hour. With a 5-mile wind, it will pump an appreciable quantity of water, but a 10-mile wind will, in some cases, multiply this amount by ten.

The water raised with a velocity of 15 to 16 miles is generally about 50 per cent. beyond that with a 10-mile wind; up to 20 miles there is a very slight increase, and beyond this the quantity is usually stationary, owing to the action of the governor.

The windmills in present use may be broadly divided into two classes, viz., the old-fashioned type with four, five or six "sweeps," and the modern annular disc wind wheel. Horizontal mills have been built, and, curiously enough, this design has attracted the greatest attention on the part of inventors, but their performance is so indifferent that it is not proposed to here devote space to them.

The driving mechanism of the older class of mill is of two kinds,—the sweeps consist either of wooden frames covered with canvas, or the sail surface is composed of a number of shutters capable of turning upon axes, so as to oppose more or less area to the wind. The sail sweep, notwithstanding its disadvantages, is still in extensive use; all that can be said for it is that it is light and cheap and gives a rather more powerful drive than a shuttered sweep of the same size. Its drawbacks are that it is not self-regulating, and the surface exposed can be only approximately adjusted to the load, or the wind, by stopping the mill and making the alteration by hand. This is a difficult and dangerous operation in squally weather. Attempts have been made to remove this objection, but, so far as can be ascertained, none of the remedies have stood the test of time.

It would be out of place to enter

A WINDMILL DRIVEN QUARRY PUMP INSTALLED BY MESSRS. J. S. MILLAR & SON, ANNAN, N. B., WHO ARE THE BRITISH REPRESENTATIVES OF THE AMERICAN WINDMILL BUILDERS THE STOVER MFG. CO., OF FREEPORT, ILL.

A WINDMILL, TANK AND ACCESSORIES ERECTED FOR THE CORPORATION OF SOUTHPORT, LANCASHIRE, FOR PUMPING SEA WATER FOR FLUSHING THE TOWN SEWERS AND FOR STREET WATERING. RESERVOIR CAPACITY, 25,600 GALLONS. THE WINDMILL CAN PUMP APPROXIMATELY 75,000 GALLONS A DAY. INSTALLED BY JOHN WALLIS TITT, WARMINSTER

upon a detailed description of the shuttered sweep, but it is pertinent to say that there are two systems under which regulation is effected. In one plan the shutters in each sweep can open or close independently of those in the others, by being connected, through bell cranks and rods, to a spring mounted upon each whip or radial arm. In the other, the shutters in all the sweeps act simultaneously, the pressure being applied by a weight acting upon a rod which passes axially through the main shaft.

The first method has the advantage of equalizing the load on each sweep, whereas the second enables adjustments to be made while the mill is running. A combination of both systems would probably produce the best results, and there appears to be no reason why the resistance of the weight should not be controlled by a centrifugal governor in the event of a very steady drive being required.

The most suitable angles for the "weather" or twist of the sails at different parts of their radii have often formed the subject of mathematical investigation. It is, however, beset with difficulties, as other factors, such as the width and number of vanes, enter into the question, and the writer ventures the opinion that a series of experiments with an artificial wind is the only means of providing reliable data.

Smeaton's famous trials with models on a whirling table were of this nature, and appear to be the only records in the English language that have been made public; but they were made a century and a half ago, and obviously stand in need of revision. A few years back, however, the Danish Government caused a set of experiments to be conducted, the object of which was to determine the form of a windmill to give the greatest mechanical effect within a given diameter.

These experiments, which were made with a large number of models and a wind produced by an electric fan, were confirmed by observations on large mills, and go to prove that the form of the sails should be as follows:—

The mill should have four arms, the sail surface being approximately rectangular, with a width of one-fourth to one-fifth of the radius and a length of about three-quarters of the radius.

The cross-section of the vane, at the tip, should not be a straight line; the leading edge should be bent or curved to an obtuse angle with the rest of the sail. The breadth of the leading or bent portion should be one-fourth to one-sixth of the total breadth of the sail.

The versed-sine of the arc or angle should be from 3 to 4 per cent. of the chord or of the straight line subtending the angle; inwards from the tip the curved or bent portion should be gradually flattened down to a straight line at the inner edge of the sail.

The bevel of the chord or of the straight line subtending the angle of the bend should be 10 degrees with the plane of motion at the tip, increasing uniformly so that it would become 25 degrees at the axis if the sail were continued through the whole length of the radius.

When the mill has a substantial body, the extremities of the sails, if they are of canvas and weathered, as above indicated, will flap when passing it, owing to the compression of the air between them and the body. To avoid this, the tips of such sails should be set square, so as to coincide with the plane of motion, and the versed-sine of the arc should be increased to from 4 to 6 per cent.; but at a distance inwards equal to the width of the sail, the weather angle should be the same as at the extremities of the former type.

The speed of the tips should be 2.4 times that of the wind, except when they are square, in which case the speed should be increased to 2.8.

The work yielded by a mill constructed under the foregoing conditions should be 0.04 foot-pound per square foot of sail surface, with a wind velocity of 3.28 feet per second, and will increase with the cube of the speed of the wind, subject, of course, to the limitations previously pointed out.

The conclusions cited agree, in the main, with existing practice, and confirm Smeaton's contention that increasing the area of the sails, relative to that of the circle swept by them, beyond a certain point does not augment their power in the same

LOUIS CASSIER

IN MEMORIAM

AMONG the victims of the appalling railway disaster on the London & South-Western Railway, on July 1, was Louis Cassier, the founder of this magazine. Speeding from Plymouth to London, the fast night express, which carried mails and passengers from the American Line steamship "New York," left the rails near Salisbury. Twenty-three of the passengers were killed and many others injured, and the wreck generally was complete.

Mr. Cassier was on one of his frequent trips between London and New York, and, though usually accompanied by Mrs. Cassier on these journeys, was alone this time. He was born at Boston in 1862, and immediately after leaving school began work in that city, in the advertising department of one of the daily newspapers. This he continued until, late in the eighties, he went to New York, and there engaged in miscellaneous advertising work, principally in connection with the American edition of the "Illustrated London News."

Of restless disposition, with a vast amount of nervous energy seeking new outlets constantly, he soon felt the need of expansion in directions other than those which he had previously followed. Though not an engineer, engineering appealed to him as a field for publishing exploitation, —exploitation of a new kind with hitherto untried methods,—and the result, after a comparatively brief period of planning, was the first number of the magazine bearing his name,—a magazine of illustrated engineering, intended to deal with steam, electricity, power. This was in November, 1891.

Disaster was freely predicted for the venture, but with the buoyancy of spirit and courage of conviction which characterized him, the work of developing the new publication was pushed unremittingly. In the fall of 1894 a London edition of the magazine was started, and thus on both sides of the Atlantic the publication began to grow and spread to the gratifying proportions which it now has.

Not content with this measure of success, however, Mr. Cassier, late in 1903, purchased "The Electrical Age," a periodical of many years standing, neglected and indifferently managed until then, but of promising possibilities. The Cassier Magazine Company had meanwhile been formed, with "The Electrical Age Company" as a subsidiary organization, and with Mr. Cassier as president of both, and under this new ownership, "The Electrical Age," reinvigorated, started out on a new career in 1904, with all signs pointing to as successful a future as that of CASSIER'S MAGAZINE. An English edition also of "The Electrical Age," with offices in London, was projected when death overtook him.

Mr. Cassier was a cosmopolite,—at home on both sides of the Atlantic,—with a host of friends and acquaintances. His personality was striking. To meet him was to remember him.

Original, resourceful, enterprising, he combined in himself most of those qualities which stamp themselves upon men's memories.

LOUIS CASSIER

From Other Points of View

Corporation Management

From the "Manufacturer"

A GREAT abuse has of late years grown up in corporations which do a large business, or hold and use great properties, namely, the exaggeration of salaries and perquisites. In the first place, the acceptance of several salaries from different companies or corporations is always to be distrusted, inasmuch as the underlying supposition ought to be that a man owes all his time and strength to the company which pays him an adequate salary, and that his interest should not be divided between different corporations or different services. In the next place, multiple salaries are injurious, because they overpay the recipient. The huge single salaries of recent times also overpay their recipients. The excuse for them has been that in conducting a large business the right man is cheap at any price, and the wrong man dear at any price. The fallacy of this argument is that the exaggerated salary will not really get or keep the best man,—indeed, is not needed in order to get or keep him.

The best man for any large service is the man who has such a natural taste and faculty for that kind of work that he will take it and keep it without any very keen attention to the amount of salary, provided the amount be sufficient to provide for him a suitable mode of comfortable life and a suitable provision for old age or disability. His reward comes chiefly from gratified ambition, possession of power, and sense of achievement.

The workingman who earns $2 or $3 a day cannot see the justice in paying the president of a railroad, or a bank, or of an insurance company $300 a day; and he never will see it. He will never believe that any man can fairly earn such a salary. He will never admit that the salary of a manager should be proportionate to the agglomerated bulk of the business he manages, while the workman's wages remain proportionate only to his own individual daily productiveness; and herein the workingman is right.

The first duty of a corporation toward its employees is to provide those external conditions which will promote health, cheerfulness, and vigour in the working people. Every corporation should endeavour to secure for its workmen freedom for the play of individual powers, and should keep before every competent workman the hope and expectation of improving his lot as time goes on.

In the next place, every corpora-

tion should try its best to procure for its employees steady employment, thereby promoting satisfactory conditions for family life, and securing a resident population instead of a nomad population. Again, every corporation should study the means of prolonging the earning of wages beyond the period of greatest efficiency.

Further, a corporation whose business requires the handling of its money by numerous agents should provide all possible checks and guard against dishonesty on the part of such employees. A corporation that neglects such precautions will train thieves, instead of honest men.

No corporation has a right to submit to, encourage or connive at any monopoly of the kind of labour it buys, because the corporation which yields to such a monopoly abridges the just liberty of workingmen, and liberty is an indispensable condition of public and private happiness. It is another phase of the same principle, that no corporation should seek, by force or indirection, to establish a monopoly of its own.

Temperature Effects on the Power of a Textile Mill

Wm. F. Parish Before the New England Cotton Manufacturers' Association

ONE of the great influencing factors upon the power of a mill is the temperature. It is the effect of this that makes a mill start up hard in the morning, especially on Monday. I know of an extreme case where it took the engineer at one boiler, the fireman at another, and the manager at the third to keep the engine going for the beginning of each day. The reason was supposed to be that the engine was not large enough. The real reason was, improper lubrication, largely affected by temperature, with the further influence of relative humidity.

Temperature will always be felt more if a mill is being lubricated improperly. The main reason why it is felt at all is through its effect upon the lubricant. Humidity affects the belts or straps, and more especially the cotton bands, its action upon the belts being just the reverse of that upon the bands, so much so that in many mills the power of the engine is not affected, as the tightening of the spindle bands offsets the loosening of the leather belts or straps. Were it not for the counter-action of the driving belts, humidity would affect the speed of the spindles, and an increase of humidity would result in an increase of speed, as the bands would be tighter and would slip less. The power, however, would be increased by the extra pressure on the bolsters, and by the higher rotative speed of the spindles, assuming, of course, that all other conditions were equal.

The speed of the spindles is affected through lubrication, the revolutions increasing as the resistance decreases, caused by lessening the band slippage at the whorl, or warve. When a good percentage of power is saved through the better lubrication of spindles, the lessened resistance of the frames reduces the slips of the belts from main shaft to frame.

The temperature affects the power through the lubricant, as the following hypothesis will show:—A mill with 1000 horse-power and a poor lubricant might require up to 1300 horse-power to start in the morning when the lubricant was cold, because then it possesses but little fluidity. No abrasive friction is caused, as the actual bearing surfaces are farthest apart when the lubricant is cold. The heat from the spindle or bearing is the result of oil friction only, and this increases the fluidity of the oil, increasing its ease of operation, and reducing the amount of power necessary to operate the mill. The increased temperature of the bearings gradually has its effect upon the temperature of the room, upon the relative humidity, and also finally upon the power.

The Flaming Carbon Arc Lamp

L. B. Marks Before the National Electric Light Association

THE lighting interests now have offered for their consideration another lamp of the open-arc type, popularly known as the flaming carbon arc lamp. Let us examine briefly some of the characteristic differences between the flaming-carbon arc, the ordinary open, and the enclosed arc.

In the open arc lamp, as commonly used, the carbons are solid and comparatively free from impurity. The arc is about one-eighth of an inch long, and the light emanates almost entirely from the incandescent points, less than 10 per cent. coming from the arc itself.

In the enclosed arc the carbons must be as pure as possible. The arc, as ordinarily operated, is about three-eighths of an inch long, and, as in the case of the open arc, most of the light issues from the incandescent carbon tips.

In the flaming arc lamp, on the other hand, the carbons are cored and mineralized, that is to say, provided with certain mineral substances either in the core or body of the carbon, or both, which, when feeding into the arc, greatly increase the light-giving efficiency of the latter.

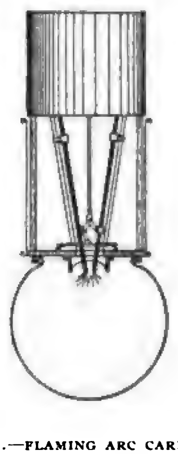

FIG. 1.—FLAMING ARC CARBONS BOTH FEEDING DOWNWARD

The volatilization of the mineralized carbon produces fumes and a considerable quantity of ash, deposits of which are made largely in the portion of the lamp immediately above the arc. In the flaming arc lamp, unlike the open and the enclosed arcs, the bulk of the light emanates from the arc itself, only a comparatively small portion coming from the carbon points. In the lamp with the carbons co-axially arranged (see Fig. 2), the length of the arc is about five times that of the ordinary open arc, taking the same current and voltage, or about five-eighths of an inch. When both carbons are arranged to feed from above (as in Fig. 1), the arc tends to creep up the sides of the carbon unless special provision is made for holding it in place, so that in all flaming arc lamps with inclined carbons a magnetic field is provided in the lamp by which the arc is continuously blown downward, resulting in a long flame measuring 1 inch to 1½ inches in length. (See Fig. 3.)

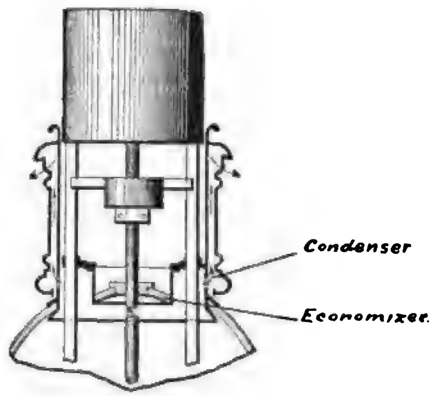

FIG. 2.—A FLAMING ARC LAMP WITH THE CARBONS ARRANGED CO-AXIALLY

Owing to the rapidity with which the carbons are consumed in the flaming arc lamps, it has been found necessary to shield the tips, as far as possible, from "washing" of the air currents in the globe. For this purpose an "economizer" (Fig. 4) or

chamber of highly refractory material is used, which surrounds the ends of the carbons (in lamps in which the carbons are arranged side by side) or encircles the upper carbon (in lamps in which the carbons are arranged one above the other).

The vapour which results from the burning of the mineralized carbons condenses, for the most part, on the economizer and contiguous portions of the lamp casing. Sometimes a special form of condenser is provided to receive the vapour deposits. As the colour of the condensed vapour is whitish, the deposits above the arc assist in reflecting the light downward. The arc is extremely sensitive to currents of air in the globe and to variations in the magnetic field and regulating mechanism of the lamp.

The regulating mechanism is housed as completely as possible to prevent access of the fine ash and the destructive fumes from the arc. It is not deemed necessary to give the details of the regulating mechanism of the various lamps of the flaming arc type, as in principle the mechanisms are the same as some of those of the older types of arc lamps with which we are familiar. The flaming arc lamp gives a little over five times the total luminous flux of the enclosed arc lamp using the same amount of power at the arc.

For the purposes of street illumination the highly efficient yellow light of the calcium carbon is, in general, suitable, but for interior illumination where colour values are important the yellow-light flaming carbon lamp is objectionable. Under the light of this lamp white material appears cream-coloured, the shades of yellow are intensified, and the colour values at the violet end of the spectrum are naturally distorted. It is quite impossible to distinguish different shades of dark blue from one another, all of them appearing black. With the white-light flaming carbons, however, most of the colours have nearly their daylight value.

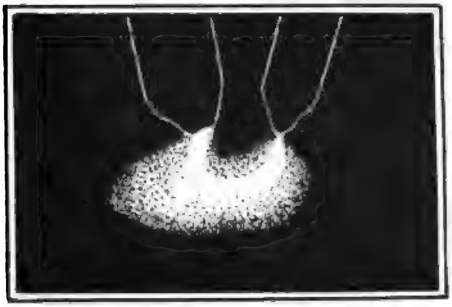

FIG. 3.—FLAMING ARC BETWEEN INCLINED CARBONS. ARC BLOWN DOWNWARD BY MAGNET

In the very nature of things the tendency of a long arc operated in the manner employed in flaming arc lamps is toward unsteadiness. The variability of air currents in the globe, the lack of uniformity in the chemical constituency of the mineralized carbon, and the action of the magnetic field (where such is employed), these and other difficulties conspire to produce unsteadiness in the light.

The distribution of illumination of the type of flaming arc lamps now in use is quite different from that of the enclosed arc lamp. Most of the light of the flaming arc lamp

FIG 4.—A FLAMING ARC ECONOMIZER

is thrown downward in a zone from 30 to 90 degrees below the horizontal, the amount of illumination dropping off quickly toward the horizontal.

Engineers' Commissions

Dr. R. W. Raymond in an Address at Lehigh University

PERHAPS the commonest question of casuistry occurring in modern business is that of commissions. As the agent of your employers, you have to purchase a steam engine. After getting the prices and inspecting the engines of all the manufacturers, you decide upon the machine most suitable, on the whole, for your purpose, and in all legitimate ways beat down the sellers thereof to their lowest price. Just as you are about to close the bargain at the price, they say:—"This covers, of course, your commission of 10 per cent."

When you reply that you do not expect any commission, and suggest that, instead of paying it to you, they take it from the amount of the bill they send to your employers, they tell you that, according to some trade agreement, they cannot charge a lower price, but can pay a commission to the selling agent. Now, you are not the selling agent, but the purchasing agent, and, explaining this difference to them, you tell them that you will be in honour obliged to pay your employers whatever commission may be paid you. To this they reply, with a kindly but cynical smile, that they do not care what you do with the money after you have got it, and you see clearly that they regard your protestations of honour as part of the formula which precedes your acceptance of the money. They do not really believe that you will not keep it if you get it.

I am repeating an episode of my own experience, and perhaps my solution may be of use to you. I declined the commission offered in currency; required it to be put in the form of a check to my order; indorsed that check to the order of my employers and presented it to them, leaving them, if they saw fit, to return it to me as a legitimate perquisite of my position. They did not see fit, and they were quite right. But the most important feature in my action was that the return of the check, thus indorsed by me in their favour, convinced the manufacturers of my honesty as no amount of high-toned oratory on my part could have done.

Getting the Capacity of an Irregular-Shaped Tank

W. Osborne in "The American Machinist"

TANK does not seem to be exactly the term to use to describe this irregular-shaped vessel, which looks as though someone had started to build a boiler and had changed his mind. The body is of varying diameters, and the heads look as though they might have been intended for tank-car tanks. Perhaps the original builder had been in the tank and boiler business and had used the left-overs and the culls, and had helped out a little where they did not come together, and this was the result.

Anyone who tries to account, in a logical way, for all the things that he sees will never be without occupation for his spare time; no, not even if all his time is spare. I am not going to account for the shape of this vessel, nor for the way it chanced to be where it is, nor for the many uses it has been put to. It may have had various names in the course of its travels, and these would likely vary with the use it chanced to be put to. Now it is known as a tank, with various prefixes.

It so happened that the owner wanted to know the capacity of this tank one day and told his mechanical engineer to get it for him. It is not a pleasant thing to have a man in

authority want to know such a thing about such an object as that tank, but Jones took his steel tape and went to measure. The man who helped to do the measuring was filled with wonder to find that anyone had education enough to figure out such a thing.

"If you have much of this kind of work to do I don't envy you your job," said he, wanting to be friendly.

"This is a very simple thing," said Jones, with the air of a man who felt rather offended because he had been put on such simple work, "and the worst part of it is getting the measurements out here in the dirt and cold." "I'll do anything I can in the way of seeing that you get all of the measurements you want, but when you get to the figuring I am not in it."

Jones was somewhat of a new man about the works, and Pete, who was a sort of handy man, or man of all sorts of odd jobs, wanted to do his best to get on a friendly footing.

By and by another man was measuring the tank. Not wishing to be personal, I will call him Smith. Pete again helped. He said nothing about having helped the other man, although he did his best to be obliging with this one. Pete had long ago found out that it does not pay to know too much about the business of others, but this measuring set him to thinking.

When Jones had taken his figured result to the manager, who may be called Brown for purposes of identification, that worthy wanted to know how he had gotten it. When he saw the array of figures, he said:—"This happens to be a case where I want close results. Please go over the matter carefully again."

Then Smith was called without Jones knowing anything about it, or Smith knowing that Jones was on the job.

The second result produced by Jones differed quite a bit from his first one.

"You are sure that this is the capacity of the tank, are you?" Brown asked.

"Yes, sir. You will find that is very close. Owing to the extreme irregularity of the tank, it may not be absolutely correct, but it is well within any practical requirements."

When Smith produced his results he was also sure that they were right, but as they did not agree with the figures that had been received from Jones, Brown referred the matter back to each of them. He then took a walk down to where the tank sat. Pete was at work near by.

"Pete, how much do you think that tank will hold?" he inquired.

"I would guess that it holds about a hundred barrels, but if I wanted to know for sure I would measure it," said Pete.

"How would you measure it?"

"I would just get the hose and stick it in the top, and while the water was running in I would get an empty oil barrel and take out one head and put the bung in, and then I would measure forty-two gallons into it while it set on the scales. That would let me get the weight, too, and if it didn't come out right I would measure it over again. Then I would make a mark around the barrel to show where the water came to. When I got the tank full all I'd have to do would be to draw it out into the barrel, and when the barrel was full up to the mark over she'd go, and I'd fill her up again.

"I would put down a mark for every time I got the barrel full."

"Do you think you could stop the water just at the mark every time?"

"I'd do the best I could, and I'd have a pail and an old can here. If I didn't get enough into the barrel I could put it in from the pail, and if I got too much in I would dip some out into the pail. I think I could stop close enough for that. If I couldn't, I would get another pail."

"Go ahead and do it in the way you say, and do it carefully, and bring me your measurements as

soon as you get them ready."

In the course of time Pete's results were on Mr. Brown's desk along with those of Jones and Smith, and they did not agree with either of the others.

Mr. Brown sent for Jones and Smith.

"Gentlemen, there is something wrong with your statements as to the capacity of that tank. If you were both right your results would be the same, but they are not. I am inclined to think that you are both wrong."

"I was exceedingly careful in taking my measurements, and used the very best formulas," declared Jones.

"I used extreme care and made due allowance for every departure in the workmanship from the true curves, and carried my computations out to the—" Smith was very earnest.

Brown interrupted. "Gentlemen, I have no time or desire to go into the details of the matter. That part is for you. I do not care how this work is done so that it is accurate, and done at a reasonable cost. Go and work together, and when you get a result which you know to be right let me have it."

It is hard to surrender a point when you know that you are right, and that tank was a beastly shape. The result finally arrived at might be called a voluntarily arbitrated result. Neither of the men believed it to be as near right as his result obtained while working alone, but each one thought it to be nearer than the other fellow's.

When this result was taken to Mr. Brown he shook his head. "Wrong again. Here is the capacity of the tank," and he produced Pete's figures. "It cost about two dollars to get them, and I believe they are right. You men have done a lot of hard work, and it has cost several times that, and it does not amount to anything."

"How did you get that result?" It was as if Jones and Smith were speaking a piece together.

"I had Pete fill the tank, and then run it out into a measured barrel. Either of you could have done that. You could have measured the water into the barrel yourselves if you wanted to; and noted the temperature; and put on any other refinement you thought best. It would have cut out the large element of guess-work which your methods made necessary.

"I do not know how closely Pete worked in doing his work, but I have lots more faith in his methods than I have in yours. The chances for mistakes are very few. While we are at it I want you to go and fill his barrel to the mark he puts on and see how many gallons you make it. Don't forget in doing your work here that it is results, and results only, that the company is able to pay for."

Pete's gauge of that tank still stands.

There isn't any moral in this unless it is to see that all tanks are made of regular shapes, or else that all irregularly shaped ones are put to uses where their capacity does not have to be known.

Figuring often saves a lot of hard work, and work often saves a lot of hard figuring.

Fireproofed Steel Construction

William Sooy Smith Before the Western Society of Engineers

THE essential characteristics of a fireproofing material for buildings are:—

1.—It must itself be incombustible.

2.—It must be, as nearly as possible, a non-conductor of heat.

3.—It must be strong and durable.

4.—It must stand heating to redness and plunging into cold water without cracking.

A fireproofing material, possessing all the essential properties enumerated, has been discovered. If the

steel skeleton is covered with metal lathing, strong wire cloth or expanded metal lathing, heavily plastered inside and covered with stucco on the outside, roof and all, using an asbestic or other equally good fireproofing material, mixed with quicklime on the inside and Portland cement on the outside, it will be safely protected from corrosion and heat and the stucco will be as hard and durable as stone. In case the plaster and stucco are shattered (which can hardly occur, as they are strongly reinforced by the steel lathing) and knocked off by heavy strains or shocks, the steel frame will not be injured nor will life be destroyed by the fall of the small fragments. In the light of these facts it would seem to be very much out of place to load the steel structure with the enormous weight of a heavy and clumsy integument of brick, concrete, or stone, which adds but little strength, only great weight, and thus making the building weaker instead of stronger, not safe but more dangerous, less impervious to heat or cold and far more costly, both in foundation and superstructure.

Points on Ferro-Concrete Work

Sven Bylander Before the Junior Institution of Engineers

THE materials for the concrete in ferro-concrete construction must be of a much better quality than for ordinary concrete. In the first place, the aggregate must be of a smaller size, stone or gravel being crushed to pass ¾-inch mesh. Coke breeze or cinder is not satisfactory. The proportion between broken stone or gravel to sand and cement must be such that there will be no voids in the finished concrete, and the concrete should be put in in a wet state, and in thin layers properly tamped so as to thoroughly cover and embed the steel. The concrete should also be made rich, in order to prevent penetration of water as far as possible.

The tests of small specimens in laboratories are not to be relied upon, and full-size tests of members, such as occur in actual practice, are more to be trusted. A great number of full-size tests have been made, and, from the results obtained, it can safely be said that ferro-concrete is not at the present time simply an experimental material.

One important point which occurs in testing members is that cracks in the concrete are not visible, although, according to calculations, the ultimate strength of the concrete has been exceeded. The introduction of steel reinforcement has produced this phenomenon, and the first writers on ferro-concrete claimed that the property of concrete when introducing steel is entirely changed, and that ferro-concrete must not be considered as a combination of concrete and steel, but as a new material.

Later experiments point, however, to the fact that the concrete really is cracking as soon as the ultimate strength is reached, but that the cracks are very close together and are not visible to the eye. These cracks are generally called hair cracks, and if ferro-concrete members are loaded exceedingly high these hair cracks will increase and become visible. It may, therefore, be considered as a fact that the reinforcement in members subjected to tension will not prevent the concrete from cracking, but that the reinforcement will force the concrete to crack uniformly, and not show any big cracks.

This phenomenon is best illustrated in a concrete wall where steel has been embedded to prevent cracking of the concrete due to change in the temperature. It is found that without the steel the concrete is more liable to crack, and the cracks will occur in the concrete wall where the concrete has the smallest resistance to tension, and the adjoining part of the wall may remain intact.

If steel rods are introduced, the

strength of the wall will be more uniform throughout, and the steel will take up the tensile stresses and force the concrete to remain in a certain position. The occurrence of hair cracks will not materially affect the compression strength.

Experiments have shown that cement mortar is an excellent material for protecting steel against corrosion, and when we consider that iron bridges exposed to the open air and locomotive gases have done their work for more than fifty years, we can safely say that steel embedded in concrete, under ordinary conditions, will be preserved for a much longer time, as cement is a much better covering for steel than is paint.

It should be noted that ferro-concrete should not be constructed in frosty weather, as the construction may then be unreliable.

The Early Use of Iron

Bennett H. Brough in a Recent Lecture at Glasgow

As to the question whether prehistoric implements of iron were made from a meteoric nickel-iron alloy, it may be said that such an origin for early iron implements is open to considerable doubt, owing to the difficulty of working meteoric iron. Some meteoric iron is malleable, and there are undoubted cases in which it has been successfully forged. The difficulty remains, however, of tools suitable for cutting meteoric iron not having existed in early days. The first discovery of iron was probably due to the accidental melting of a rich iron oxide with charcoal.

Iron was undoubtedly used in the building of the Pyramids, 3000 B. C., the working of granite and porphyry being scarcely conceivable without steel tools. There is in the British Museum an iron sickle which was found under one of the sphinxes at Karnak. Another historic piece of iron, also preserved in the British Museum, is part of a tool, and was found in the Great Pyramid, and so must be nearly 5000 years old. This is more interesting in the light of recent metallurgical practice, as it contains not only nickel, but also combined carbon, thus showing that it is not of meteoric origin. A further anticipation of what we look on as modern practice was the iron bedstead of Og, King of Bashan. He was "of the remnant of giants," as well he might have been, for his bedstead was 16 feet 6 inches long and 7 feet 4 inches wide.

Another interesting piece of early ironwork is more modern, dating back to less than a thousand years B. C. This is the iron pillar at Delhi. It is 50 feet high and 16 inches in diameter, and is made up of 50-pound blooms welded together.

In the Far East the use of iron and steel has been traced back in China to the year 2357 B. C., or about eleven hundred years before Japan was colonized from that country. The Japanese are said to have followed a method of making steel which had the merit of simplicity. They buried forged iron bars in marshy ground, and what was left of them after eight or ten years, by some curious alchemy, came out steel.

The iron industry of England is, beside that of Egypt or China, quite modern. The Emperor Hadrian founded an arms factory nearly 1800 years ago, getting iron from the Forest of Dean mines; and the slagheaps in Sussex testify to the extensive iron works in the south during Roman occupation.

The Economic Value of Niagara Falls

H. W. Buck, of the Niagara Falls Power Company, in "The Outlook"

The economic value of Niagara Falls is probably understood by very few of those who protest and petition against its commer-

cial use. The total hydraulic energy of the falls, if all were developed, would represent about 3,500,000 horse-power. To generate one horse-power continuously for a year by a steam engine requires about 13 tons of coal. To generate, therefore, continuously 3,500,000 horse-power by steam would require about 50,000,000 tons of coal per year. To generate electric power by steam with the most modern steam plant costs not less than $50 per horse-power per year, allowing for fixed charges and operating expenses. Niagara power can be generated and sold in large quantities for $15 per horse-power per year, or for $35 per horse-power-year less than is possible from the use of coal and the steam engine. From the above it will be seen that if all the hydraulic energy of the falls were utilized for power purposes there would result to the country an annual saving of $35 per horse-power for 3,500,000 horse-power, or $122,500,000, and, in addition, there would be an annual saving in coal consumption of 50,000,000 tons. These figures illustrate what it costs the people of this continent annually to maintain Niagara Falls as a spectacle. They represent the saving to those who would consume the power and not the profit of those who might own the power developments. This waste involved in prohibiting the development of Niagara power might be likened to a great conflagration in which 50,000,000 tons of coal were annually consumed. Such a conflagration might be one of the most magnificent sights in the world, and people might come from all parts to view it, but the human race would certainly be justified in using every effort to stop the waste by putting out the fire.

ARTHUR WILLIAMS

The New President of the National Electric Light Association

IN the central station field there is probably no one more widely known than Arthur Williams, born in Norfolk, Va., August 14, 1868; although still a young man, he is one of the pioneers. Recognizing the great possibilities of the electrical field, he abandoned an early desire to enter the United States Naval Academy and identified himself with Messrs. Rennie & Smith, the authorized wiring contractors of the old New York Edison Electric Illuminating Company, in September, 1884.

On February 6 of the year following, at the solicitation of the superintendent, Mr. Charles E. Chinnock, he entered the services of the Edison Electric Illuminating Company, and was identified with the early history of the old Pearl Street station, in the city of New York, which was the very starting point of the electric lighting industry in America. His work at this time was of a miscellaneous character, such as general repairs, lamp changes, reading of meters, etc. Step by step he advanced in importance in the company's organization, becoming station regulator, electrician, superintendent of one of the lighting centres or districts, and superintendent of underground construction.

In 1890 he assumed the position of general inspector, and built up an organization which combines the function of a general agency and advertising bureau with those of general inspection. To his unusual ability in organizing this department, in obtaining the best men for its purposes, and by directly repre-

senting the company to the consumer, the New York Edison Company owes much of its success in the increase of customers' installations.

In home and foreign electrical circles Mr. Williams' intimate knowledge, based also upon his practical experience, of the commercial relations of the central station is regarded as authoritative, and he has made a number of valuable contributions to the literature in this field. At the Detroit meeting of the Edison Association in 1896, his paper on "The Relations of the Electrical Supply Companies to Their Customers" was considered most able and convincing. At the annual meeting of the American Institute of Electrical Engineers at Saratoga in 1899, his reply to a paper on "Isolated Electric Light Plants," which had been read before the Institute, was effective in combatting many mistaken ideas relative to central station service. In 1900, at the Saratoga meeting of the Association of Edison Companies, he read an exhaustive paper on "Electric Elevators," dealing with the history of the industry and with the comparative efficiency and economy of electric elevators and of other classes.

In 1899 Mr. Williams was elected vice-president, and two years later president, of the New York Electrical Society, at whose meetings he displayed the same energy, executive ability, and discretion which have signalized his business life.

Municipal ownership is a subject of vital interest to Mr. Williams, and, through his extensive reading and research, he has become an authority concerning it. He has studied its workings impartially, both in this country and in Europe, and the result is a valuable report upon this subject to the National Electric Light Association.

A man of tireless activity, Mr. Williams' membership in various clubs and associations affords him pleasure and relaxation. The American Institute of Electrical Engineers, the New York Electrical Society, the National Arts Club, the Municipal Art Society, and the Union League Club, of New York, claim him as a member. The latest honour conferred upon him was his election to the presidential chair at the recent annual convention of the National Electric Light Association.

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JAMES GILBERT WHITE

PRESIDENT OF J. G. WHITE & CO., INC., NEW YORK

CASSIER'S MAGAZINE

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JAMES GILBERT WHITE

A BIOGRAPHICAL SKETCH.

By The Editor

IN the long list of British and American engineers who have won recognition, there are many who have guided and brought to successful conclusion important engineering work requiring accuracy, specialized skill, force, and initiative. But it is notable that relatively few of these combine with technical talent of a high order the requisite ability to mould and blend the conceptions installed by scientific training into elements of a well-conceived, broad, generous, and helpful business policy.

To accomplish this, there must be combined in the individual more than a natural taste for physical research, scientific analysis, mathematical accuracy, and enduring persistence. Men of this type are apt to be of angular characteristics, not always generous towards the plans, theories, and schemes of others, and often so intent upon the development of a specific thing as to be unmindful of the help that comes from association of ideas and the inspiration received from others and unappreciative in recognition of well-intentioned efforts of assistance.

Great achievement can seldom be gained through the concentration of a single mind. There is much good to be derived from an association of ideas, and in the last analysis it will be found that the great men are those who have built up huge structures with the material cast aside by their less observing, less generous, but probably not less earnest coworkers.

It may be fairly said that James Gilbert White has taken every step in the engineering field that leads to prominence in engineering. His intent at all times seems to have been—and this, particularly during the strictly educational period of his life—to broaden his training while not departing from the essentials of an engineering career.

Too often in youth the necessity is forgotten of carefully preparing the foundation upon which a career is to be based. The tendency is to be too generous of one's time toward those subjects which open up the practical and semi-theoretical branches of the particular work that has excited interest. It is, however, not on these

things that a student should spend his time; his most serious thought and greatest concentration should be reserved for those hours when he is to attack the most difficult and often the least attractive subjects of his course.

The knowledge derived from the most difficult studies is often little used by the young engineer who is entering upon his life's work. For years, possibly, the pages on which much time has been spent will not be recalled nor apparently be productive. It is not the deepest stone in a foundation which feels the first pressure of the weight carried in the lower stories of a building; but as the building grows, the pressure downward penetrates further and further until finally the deepest laid courses of the foundations come into service, and in a most important degree carry their share.

James Gilbert White was born at Milroy, Pa., in 1861. His father was a clergyman, born in Western Pennsylvania, of Scotch, Irish, and English stock. He was a man of high moral principles and living, more than usual intelligence, liberal ideas, and sturdy, independent thought. Mr. White's mother is a member of a family well known in Central Pennsylvania,—the Beavers. Her brother, General James A. Beaver, at one time Governor of Pennsylvania, has a fine record, made during the American Civil War, in which he was wounded severely on three separate occasions, one of these casualties resulting in the loss of a leg. Governor Beaver is now on the Superior Court bench of his native State. The Beavers are an old Pennsylvania Dutch family, some of the ancestors having come to Pennsylvania early in its history from Alsace. Through his great great grandmother, a Miss Guilbert, Mr. White also inherits a trace of French blood. Several of his ancestors were active during the American Revolution.

In 1877, when he was 16 years of age, young White entered the Pennsylvania State College, taking the course in arts, and graduating with the degree of A. B. in 1882. During the summer vacations of his college course he devoted a large part of his time to such engineering work of one kind or another as would give him a better appreciation of his college work and enable him to more thoroughly understand and appreciate the bearing of his scientific studies upon industrial life. His most extensive summer work was done in 1881, when he spent considerable time with a party engaged in surveying in Northern Pennsylvania, and later, in the civil engineering department of the Cambria Iron Company, of Johnstown, Pa. After receiving the degree of A. B., he returned to the Pennsylvania State College and concentrated his time upon civil engineering. Immediately thereafter he tested his newly acquired knowledge by putting in a summer on the reconnaissance and location surveys of a steam railroad in Central Pennsylvania.

He seems constantly to have been drawn from the class room into the field of practical engineering activity and back again to the class room. In 1883, he entered Lehigh University with the intention of studying mining engineering. While there, and during the winter of 1883-1884, he became especially interested in electrical investigations, and finally determined upon making electrical engineering his life work. His final ambition, however, was not at once open to attainment; to his mind, his ground work in both practical and theoretical engineering had not been made complete.

One of the chief essentials of the finished engineer is that he shall have an exact conception of the means and methods employed to perfect the workmanship of engineering structures. In the case of many engineers of the present day such experience is largely derived from college shops and workrooms, but Mr. White turned rather to the non-academic

field for this experience; accordingly, he spent the summer of 1884 with the Cambria Iron Co. in the office of the master mechanic upon work embracing the designing of various pieces of machinery required in the manufacture of iron and steel.

In 1884 Mr. White entered upon his final work as a student in college. After the summer spent in Johnstown he entered Cornell University, specializing in electrical engineering and physics.

Here he found excellent facilities for returning to and continuing his study of electricity and electrical phenomena. His work while at Cornell was highly gratifying and successful; in fact, he received a fellowship in electrical engineering, followed by the degree of Ph.D., conferred at the commencement of 1885.

In a measure, Mr. White may be judged fortunate in having accepted, after his graduation from Cornell, the position of instructor in physics in the University of Nebraska. It led him for two years to give his attention to what was, in a great part, a careful review of much of the work he had gone over while in college, with the added value of the constant suggestion which comes to the instructor from his contact with the inquiring minds of the students. It is not astonishing, however, in view of the disposition he had previously shown to make excursions into the field of practice, that he finally, in the spring of 1887, joined forces with others in originating the Western Engineering Company.

This company did a considerable amount of construction work during the years 1888-1890, building electrical railways in Omaha, Neb., St. Joseph, Mo., and Salt Lake City, Utah.

The company also supervised the installation of a hydro-electric generating plant at Kearney, Neb., in connection with which a system of distribution was devised embodying the three-wire principle with 220 volts on each side, at a time when it was yet practically untried.

After the initial work in Nebraska and other Western States had developed considerable proportions, overtures were made by Eastern interests which resulted in the Western Engineering Co. being sold to the Edison-United Manufacturing Co., and Mr. White came to New York to take charge of the department of Electrical Railway Installation covering the entire United States in the consolidated organization. However, the formation of the Edison-General Electric Co. followed soon after Mr. White's association with the Edison-United Manufacturing Co., and Mr. White resigned to develop an engineering and contracting business of his own under the firm name of J. G. White & Co.

In association with O. T. Crosby, now of Washington, Mr. White formed the White-Crosby Co., which continued until 1897 when the former name of J. G. White & Co. was adopted for the corporation then formed under the laws of the State of New York.

In 1900, after having carried out from the New York office and by several previous trips to London, a considerable amount of engineering in Australia, Mr. White established an office in London, organizing for this purpose the English company, known as J. G. White & Co., Ltd.

During his engineering experience Mr. White has supervised the design and construction of a large number of power houses, both steam and water driven, as well as complete systems of track and overhead construction, bridges, electric light and railway distribution circuits, while a number of the more important installations have received his personal attention. Among these may be mentioned the Buffalo-Niagara Falls Street Railway, and the transmission line from Niagara Falls to Buffalo. The former was built in 1895, and was one of the first high-speed interurban lines in America. It is believed to have been the first road

to use the four-motor equipment with series-multiple control now so commonly adopted for interurban service.

The transmission line to Buffalo was probably the first in America designed to carry so much as 5000-H. P. on one set of wires, and consequently presented some new and interesting problems.

The electrical engineering of the Helena Water & Electric Power Co., and that of the Helena & Livingston Smelting & Reduction Co., also presented interesting problems in the earlier days of transmission work, and a considerable part of this was done by Mr. White personally.

The London company has carried out a number of important projects, several of which have received Mr. White's individual attention. Among these may be mentioned a power plant built in the interior of Western Australia costing £150,000. The design here presented many unusual and novel features. In this case the power had to be generated by steam from water, which, at different seasons of the year, contained from 3 to 25 per cent. of saline matter.

The international scope of the work now being carried out by the companies of which Mr. White is the directing force, may be better appreciated by stating that contracts in Maine, Massachusetts, Vermont, New York, Pennsylvania, Illinois, Arizona, the Philippines, Australia, India, France, Holland, and London have been completed within the past year, or are now in force.

Work in progress under Mr. White's general direction, also includes the construction of a large number of important buildings in Great Britain by the Waring-White Co., Ltd., of London. These buildings include the Mercantile Marine Building, Ritz Hotel, and the Waldorf Hotel, in London, and the Royal Cotton Exchange, in Liverpool.

In South America, the activities now directed by Mr. White include the construction of rural tramways at Buenos Ayres, in the Argentine, the construction of a tramway system for Montevideo, in Uruguay, and the reconstruction of the city tramways and the erection of a modern power plant at Para, in Brazil. The White companies are also engaged in the construction and operation of electric light and tramway properties in Monterey, Mex.; Havana, Cuba, and San Juan, Porto Rico. The construction of the Virginia & North Carolina Coast Railroad, which extends from Charleston, N. C., to Norfolk, Va., is included in their contracts.

The White organization consists of a number of companies independently organized, but closely allied. Of these, J. G. White & Co., Inc., of New York, may be regarded as the parent company. The development of allied companies has reduced the field of activity of this company until now J. G. White & Co., of New York, are engaged in an engineering, contracting, and operating business restricted to the United States and its dependencies, Mexico, and Central America.

J. G. White & Co., Ltd., of London, are carrying out a variety of engineering and contracting work in parts of the world other than Canada, the United States and its dependencies, Mexico, Central America, and Chili. The field in Chili is covered by the Chilian Contracting Co., of which Mr. White is president. The Waring-White Co., of London, is responsible for the construction of the fine modern steel structures erected on modern American building lines, which have previously been referred to.

In Canada, the field is covered by the Canadian White Co., of Montreal. This company is very successfully inaugurating a general engineering business in the Dominion of Canada.

To promote unified co-operation among the large number of talented engineers which make up the personnel of the White companies, especially when it is remembered that

these men are widely distributed, is a matter requiring no small degree of patience and executive ability. To obtain the most far-reaching results in such an organization, it is deemed essential that each individual be given the greatest freedom of action comparable with centralized administration. The degree of responsibility which the individual is allowed to accept is limited only by the capacity of the individual, but, at the same time, in all important matters decisions are made, not as the result of individual judgment, but after concerted consideration by the engineers best qualified to treat of a given subject.

A great unanimity of purpose prevades the personnel of the White organizations. It is apparent, even to the casual observer. Mr. White is the source of this cohesive power. It resides in and emanates from him. He is a man of kind, helpful, and resourceful personality, of a type to be eminently responsible for the foundation of organized loyalty upon which the reputation of these companies has been built.

Mr. White is known to be a man in entire sympathy with all movements which look to the betterment of social conditions and the general uplifting of men, especially those of the younger generation. He is not a perfunctory member of clubs and other organizations, but takes an active interest in virtually all of those with which his name is associated. Among electrical engineers he is known as a man of generous impulses, and, in no small measure has lent active personal and financial support to important engineering movements.

At the time of the visit of the British and Continental electrical engineers to the United States, two years ago, Mr. White took an active interest in their entertainment, and in perfecting the plans which resulted in the exceptional success of the International Electrical Congress held at St. Louis. As chairman of the Electric Railway Test Commission, which has, within the past year, concluded a most important series of experiments upon electric railway equipment, Mr. White has been untiring in his efforts to promote the successful outcome of the work. The results of the commission will soon be published and will be a very substantial contribution to electrical engineering literature.

Mr. White also prepared for the International Congress of Engineers of 1904, a paper on "The Substitution of Electricity for Steam as a Motive Power." This paper has been commented upon at length on both sides of the Atlantic and has attracted a great deal of attention.

The scope of Mr. White's interest in public affairs may be well illustrated by giving a list of the clubs and organizations of which he is a member. These are the Chamber of Commerce, American Institute of Electrical Engineers, American Society of Civil Engineers, Pilgrims Society, Pennsylvania Society, Metropolitan Museum of Natural History, National Geographic Society, University Club, Metropolitan Club, Lawyers Club, Engineers Club, New York Athletic Club, Sons of Revolution, and Cornell University Club of New York; the Maryland Club and Merchants Club, of Baltimore; the Electric Railway Test Commission, of St. Louis; the Ranalagh Club, General Committee American Society, and Institution Electrical Engineers, of London; the Pennsylvania State Alumni Association, and the Lehigh University Alumni Association.

Mr. White is also president of J. G. White & Co., Inc., of New York; chairman of J. G. White & Co., Ltd., of London, and a director in the following companies:—The Waring-White Building Company, Manila Electric Railway & Lighting Corporation, Netherlands Tramways Corporation, Niagara Research Laboratories, Canadian White Co., Chilian Contracting Company, and

the Engineering & Electrical Securities Co.

Underlying Mr. White's work may be detected a well-defined purpose which seems to have possessed him from the first. Upon a small beginning, such as is open to any young man in America, has been built, first, a thorough educational foundation equally balanced between the theoretical and practical sides of engineering. Superimposed on this has been still further study, through advanced research in scientific laboratories and practical analysis in shop management and construction, until a broad fundamental training was attained upon which to build a still broader and more far-reaching engineering career.

Anyone who follows Mr. White in his writings or in his business activities is at once impressed with the culture, the technical resourcefulness, the command of practice, and the grasp upon business of the man.

SOME ALCOHOL AND GASOLENE LOCOMOTIVES

By George L. Clark

FIG. 1.—AN ALCOHOL LOCOMOTIVE IN GERMAN FORESTRY SERVICE NEAR DARMSTADT

WITH the "free alcohol" bill shortly to become a law in the United States, the use of denaturized alcohol for power purposes is likely to receive a further stimulus. Special interest is, therefore, to be found in the several accompanying illustrations of alcohol locomotives in German and South American service.

Fig. 2, for example, shows such an engine in operation at Lima, Peru, hauling a small car and having a capacity of 8 H. P., while Fig 1 shows a similar 16-H. P. machine for use on forest railways in Germany. Fig. 3 shows still another locomotive of the same class of 6 H. P. capacity, hauling boxes on a German factory railway. These interesting types of engines are of special service for industrial work for haulage in shops and yards of iron and steel works and other manufacturing establishments, as well as for mining service.

In Germany and other Continental countries the alcohol locomotive is

FIG. 2.—AN 8 H. P. ALCOHOL LOCOMOTIVE, BUILT AT DEUTZ, IN GERMANY, FOR SERVICE AT LIMA, PERU

FIG. 3.—A 6 H. P. ALCOHOL LOCOMOTIVE, BUILT BY THE GASMOTOREN FABRIK, DEUTZ, NEAR COLOGNE, GERMANY, HAULING MISCELLANEOUS MERCHANDISE ON A FACTORY RAILWAY

extensively employed with great economy, and elsewhere the increased price of gasolene is certain to produce a similar result. The cost of operation of one of these alcohol locomotives of 8 H. P. at Miesbach, Germany, at one of the mines of the Oberbayerische-Actien Gesellschaft for Kohlenbergbau, is 1.25 pfennig per ton-kilometer. Nine of these locomotives are in operation at this mine, operating in shifts of ten and one-half hours' service on a grade of 1 to 333. Two 12-horsepower gasolene locomotives are in operation at the Portland-Cementfabrik, at Amoneburg, near Biebrich-on-the-Rhine, Germany, hauling sixteen loaded cars, each having a total weight of 1800 kilograms, on a horizontal track. The gasolene consumed was found to cost 1 pfennig per ton-kilometer.

Another 12 horse-power gasolene locomotive of this type for industrial service is in operation at the Papierfabrik Neumühle, near Miesbach, Germany. At this plant the locomotive operates for twelve hours daily on a track about 4 kilometers long, having a rise in grade of 24 meters. It will handle a maximum of 55,000 kilograms on a grade of 2.5 per cent.

The forest railway locomotive in operation near Darmstadt, shown in Fig. 1, operates at a speed of from 2½ to 7 miles an hour, with a draw-bar pull of 1500 pounds at the former speed and 500 pounds at the latter speed. It is about 12 feet long, 4 feet wide and 6 feet high, and weighs, complete, ready for operation, about 12,000 pounds, developing 16 horse-power.

The alcohol locomotive shown in Fig. 2 has a draw-bar pull ranging from 350 to 775 pounds, operating at speeds from 5½ to about 3 miles an hour. It weighs 8000 pounds.

The locomotive shown in Fig. 3 develops about 6 horse-power, and weighs about 7000 pounds.

The largest alcohol locomotive constructed at Deutz, Germany, is rated at about 32 horse-power, with a range of speed from 2½ to 7 miles an hour. This engine weighs about 25,000 pounds when ready for service.

THE ISLAND OF SANTO DOMINGO

ITS NATURAL RESOURCES AND THEIR PROSPECTIVE DEVELOPMENT

By F. Lynwood Garrison, Mining Engineer

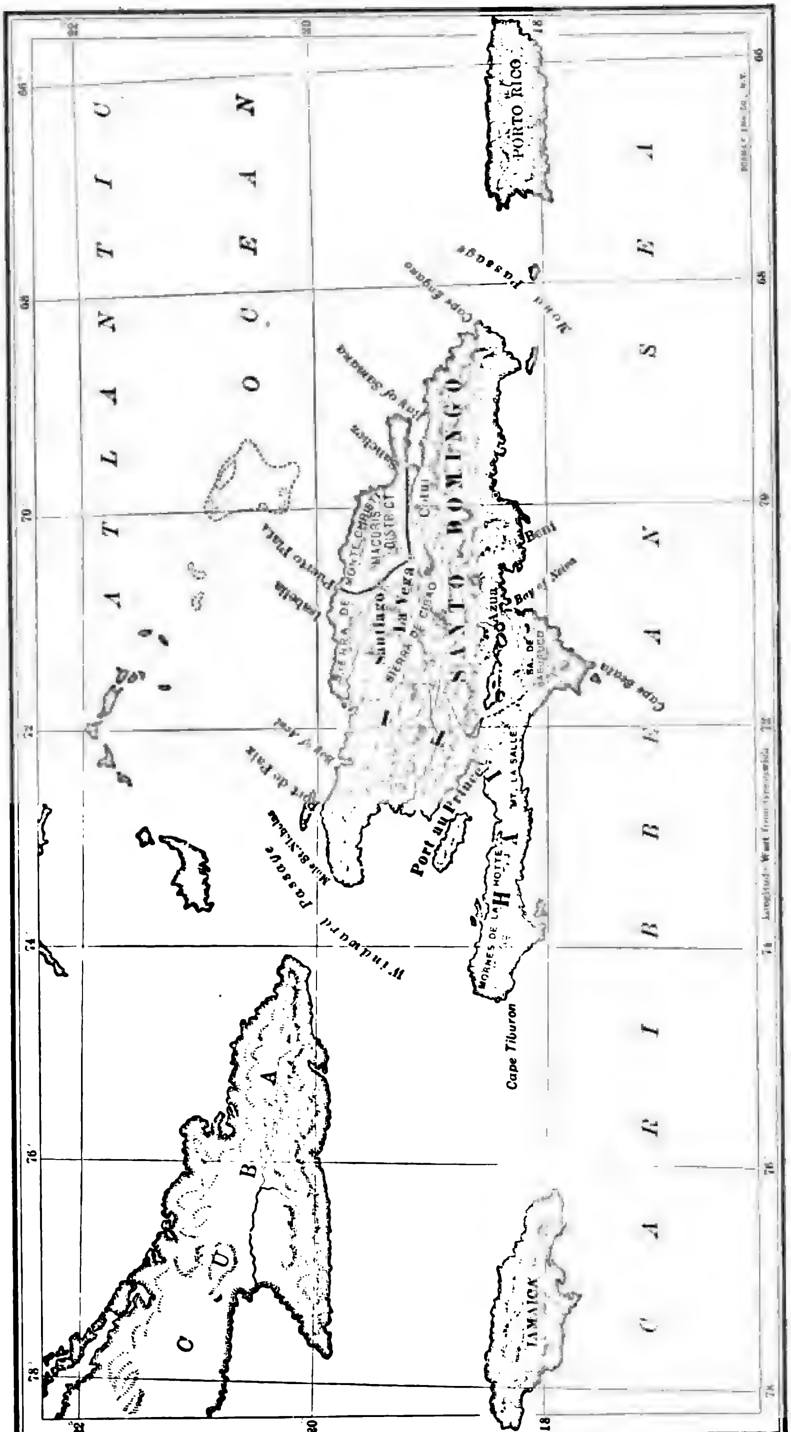
AN OLD MINING DRIFT MADE BY HENEKEN IN 1850. SEE PAGE 406

THE island of Santo Domingo, or Hayti, is the second largest of the West India islands. It is located between latitude 17° 37′ and 20° 0′ north, and longitude 68° 20′ and 74° 74′ west. It is, therefore, well within what is called the tropics, as delimited by the great circles 20° 30′ north and south of the equator, and known respectively as Cancer and Capricorn. It is well to bear this fact in mind, as, owing to certain peculiarities in climate, this condition is apt to be sometimes forgotten.

The whole island, including both the political divisions, Hayti and Santo Domingo, has an area of 30,000 square miles. It is very irregular in outline, being deeply indented by the sea on the west, and, to a somewhat less extent on the east, by Samana Bay. The greatest length, from Cape Engano on the east to Cape Tiburon on the west, is 407 miles, and the maximum width from north to south of 160 miles to Cape Beata. The windward passage of 70 miles in width separates it from Cuba, and from Porto Rico on the east it is distant, over the Mona passage, only 60 miles. Its total coast line is estimated at about 1250 miles, which is probably somewhat short of the actual truth.

Aside from every other consideration, the important strategic relation that this large territory bears to the other islands of the Caribbean Sea and to Continental centres, such as Panama, must be obvious. Its value to the United States in this respect cannot be over-estimated, and it seems rather remarkable that the American people are slow in recognizing a fact of such moment to their political, commercial, and moral dominance in this part of the world. This strategic value would be much the same even if the island were but a barren coral waste. How far different Santo Domingo actually is will be shown in some degree in the following pages.

The island is extremely mountainous; in fact, its rugosity is extreme, and in relation to the plain the altitude of its mountains is probably inferior to but very few heights in North America or in Europe. This


ATLANTIC OCEAN
CARIBBEAN SEA
CUBA
JAMAICA
HAYTI
SANTO DOMINGO
PORTO RICO
Windward Passage
Mole St. Nicholas
Port de Paix
Port au Prince
Cape Tiburon
MT. LA SALLE
Puerto Plata
Isabella
Santiago
La Vega
SIERRA DE CIBAO
MONTE CRISTI
MACORIS DISTRICT
Cotui
Sanchez
Bay of Samana
Cape Engano
Mona Passage
Azua
Bani
Bay of Neiba
Cape Beata

A DISTANT VIEW OF SOME OF THE HIGH MOUNTAINS, RANGING FROM 6000 TO 7000 FEET, TO THE NORTHWEST OF THE NIGUA RIVER

condition has had a most important influence upon the political history of the island, preventing inter-communication and tending to segregate its population into groups that have, in the course of time, become politically, commercially, and, to some degree, ethnologically, differentiated. To some extent similar conditions would have existed in Jamaica had it not been for the wise forethought of the British Government in providing that country with an excellent system of roads. In the case of Jamaica, however, the natural difficulties to be overcome were much less than those in Santo Domingo.

The mountains of Santo Domingo may be, for convenience, divided into three chains or groups, the northern or Monte Cristi, the central or Cibao, and the southern, that has no general name, but may be defined as beginning at the bay of Neiba and extending west to Cape Tiburon, thus forming the backbone of the southwest peninsula. This range is called Baburuco on the east end, LaSalle in the middle, from the peak of that name, and LaHotte toward the western end. As a matter of fact, the island is practically one great mass of mountains separated by a few large valleys, which, at a comparatively recent geological period, were narrow straits dividing chains of islands that now constitute the mountain peaks and ranges. The geological and orographical relation of this island to the other islands of

ONE OF THE OLD CHURCHES IN THE CITY OF SANTO DOMINGO

the Greater Antillean group and to Central America are of the greatest interest and importance, but unfortunately have been little studied. A few facts, however, are clear, and may be elucidated.

According to Suess,[1] the Antilles are formed of summits of a mountain chain which separate the Caribbean Sea from the Atlantic Ocean and the Gulf of Mexico. Both Suess and von Seebach[2] appear to agree that the mountains of Cuba, Santo Domingo, and Porto Rico are formed in accordance with the type of coast cordilleras of South America and

[1]Das Antlitz der Erde, Vol. 1, page 542. (English Trans.) Oxford, 1904.

[2]Central Amerika und der Interoceanische Canal. Berlin, 1873. P. 11, et seq.

the mountains of Venezuela. Suess calls these islands the Antillean Cordillera. He directs attention to the fact that toward the west the mountains appear to divide into several branches, one running from the south of Hayti through the peninsula of Jacmel and the Blue Mountains of Jamaica toward Honduras, and another from the Cibao Mountains of Santo Domingo across the Sierra Meastra of Cuba toward the Amatique Gulf in Guatemala, and thence crossing the isthmus, reaches the line of the great volcanoes. There is, perhaps, a third branch, indicated by the Sierre de Cumanayagua, in the centre of Cuba. The rocks are the same as those that form the island of Trinidad, the northern chain of Venezuela, the chains of Merida and Bogata with their southern continuation, and finally the whole series of the coast cordilleras down to the southernmost part of the South American Continent.[3]

This connection and relation with the continent have been very clearly pointed out by a number of observers, especially von Seebach. The general geology is, therefore, much the same as that of the western coast of South America and parts of Venezuela. The oldest rocks appear to be the lower Cretaceous, which system is followed here, as in Trinidad, by a highly developed series of Tertiary deposits, some members of which, according to Suess, present an astonishing resemblance to their representatives in Europe.[4] The most important period in the geological history of the island appears to have been the late Eocene, when the principal deformations took place, creating elevations to as much as 10,000 feet in the central part of Santo Domingo. It was during this time that extensive extrusions of basic rocks occurred, whose presence alone, or in association with limestones, has an important bearing upon the economic geology of the island.

According to Gabb,[5] the central core of the island is composed chiefly of syenite or hornblende granite, which appears to have been thrust up through the Tertiary beds. Whether or not the basic rocks were extruded at the same time as the

[3] Ibid. P. 549.

[4] Ibid. P. 544.

[5] Topography and Geology of Santo Domingo. Trans. Am. Philosophical Soc. Vol. XV. (1872.)

A SUGAR-CANE FIELD NEAR MACORIS

granites, it is at present not possible to say; the probabilities are they were in part, since late researches tend to show that there were several periods of extrusion, since some of the basic rocks show a decided composite structure, as though later flows had dissolved or absorbed in themselves the older volcanic ejecta. So far as known, there are no evidences of volcanic action later than the Oligocene, but, it must be remembered, very little is yet known of the rugged interior. It appears certain, however, that there are no evidences of recent volcanic activity in any of the other Greater Antillean islands.

Earthquakes are common, but these tremors may be due to other causes, or to volcanic phenomena geographically remote. All of the islands are steadily rising from the sea, and have probably been doing so since Cretaceous times, if, in fact, considered in relation to the neighbouring abysmal depths, the period of elevation does not extend back much further. Regarded in relation to these great oceanic depressions of 25,000 to 30,000 feet, like the Vergin Gorda and Anguilla, the mountain elevations in Santo Domingo are among the most stupendous in the world.

The association of basic eruptive rocks with Cretaceous limestones and other sedimentaries, and, as already mentioned, the undoubted affiliation of Santo Domingo with the Continental cordilleras, give promise of economic geological conditions on this island that are worthy of careful consideration. The unknown and unexplored in relation to natural wealth appeals to the imagination; bearing this caution in mind, some details of the subject may now be considered at length.

ON THE SOUTH SIDE OF THE ISLAND

Hispaniola, the Spanish name for this fair island, was called by some of the old historians "the mother of Hispano-American colonies," and such, in fact, it was. Here Columbus founded the first town built in the New World, and here the first

SURVEYING THROUGH THE JUNGLE

gold was extracted. There is not a particle of doubt but what the incentive for Spanish colonization was a thirst for gold, and, as an old Spanish historian has said, every energy, both human and devilish, was bent on its attainment. In some of the patents or charters granted by the Crown for later exploring expeditions on the mainland, directions relating to the conversion of the natives to Christianity were omitted, and this pious humbug no longer declared. When Columbus first landed at Watling's Island, he tells us in his journal, "I examined the natives to ascertain if they possessed gold." They explained to him by signs that by going to the south he would find a country where gold abounded.

Columbus first landed on the island of Santo Domingo at what is now Mole San Nicolas, in Hayti; thence, coasting eastward, he touched again at a spot now identified as Port de Paix (Hayti). There the natives told him the land of gold lay two days' sail to the eastward. The third landing was in the Bay of Acul, and at

PROSPECTING FOR COPPER IN THE JUNGLE

this place he first heard of the heart of the gold country,—the "Cibao." Columbus construed this to be Cipango, described by Marco Polo and now identified as modern Japan, although possibly there is some doubt as to that.

Thus, step by step, the Spaniards followed the scent of gold, and had their desires stimulated by finding it in comparatively large quantities in the possession of the native chiefs, or Caciques. The first town Columbus built was Isabella, founded on his second voyage. We know it was badly and unhealthfully located, but we are told by Columbus himself that it was established solely with a view to its contiguity to the gold regions of the Cibao. It is certain Spaniards found gold there in quantities, and that it was washed by the natives from the creek and river gravels of this region.

STRIPPING A COPPER OUTCROP AT THE SAN FRANCISCO MINES

The Spaniards soon had the natives enslaved and hard at work getting this gold by the exceedingly crude, laborious and wasteful methods of the time. The quantity thus attained was relatively enormous, and for a number of years as much as the equivalent of a million dollars in American money was annually exported to Spain. This production appears to have been gradually, then speedily, decreased, owing to the extinction of the natives, who died out with astonishing rapidity under Spanish rule and abuse. Natives were then captured and brought from other islands, and when this supply failed, negroes were imported from Africa, and the black man made his first appearance in America.

It is certain the Spaniards derived this gold from alluvial washings; it has been supposed that they actually mined gold-bearing rock, and that

NATIVE WOMEN WASHING GOLD IN A STREAM BED

the natives had previously done likewise. This hypothesis has no support; in fact, we have the best reasons for believing that aboriginal mining is a myth; all the numerous remains of the old Spanish gold-producing operations on this island point to but one conclusion, that they worked or washed the gravels exclusively.

It is true, throughout the areas covered by the basic eruptive rocks in this island there are numerous quartz veins carrying gold. The gravels and sands of all the streams that flow through these sections are gold-bearing, and are at times quite rich. The source of all the gold in the island is undoubtedly the basic rocks, and the accumulation of the auriferous gravels as the result of their erosion has been going on since the Pliocene period. With the gradual elevation of the whole island, the older gravel beds were raised above the base level of the existing streams, so that we now find gold in gravels several hundred feet higher than where they are now being accumulated. The extent of these gravel beds is surprisingly large, especially in the lower valley of the Jaina river, which is noted for its gold-bearing propensities, and whose gravels was the source of much, if not most, of the gold obtained in the old Spanish days.

The gold in these gravels is, as a rule, remarkably pure, containing but little silver,—the usual adulterant, so to speak, of most alluvial gold. Its probable general average of fineness in quality is somewhere

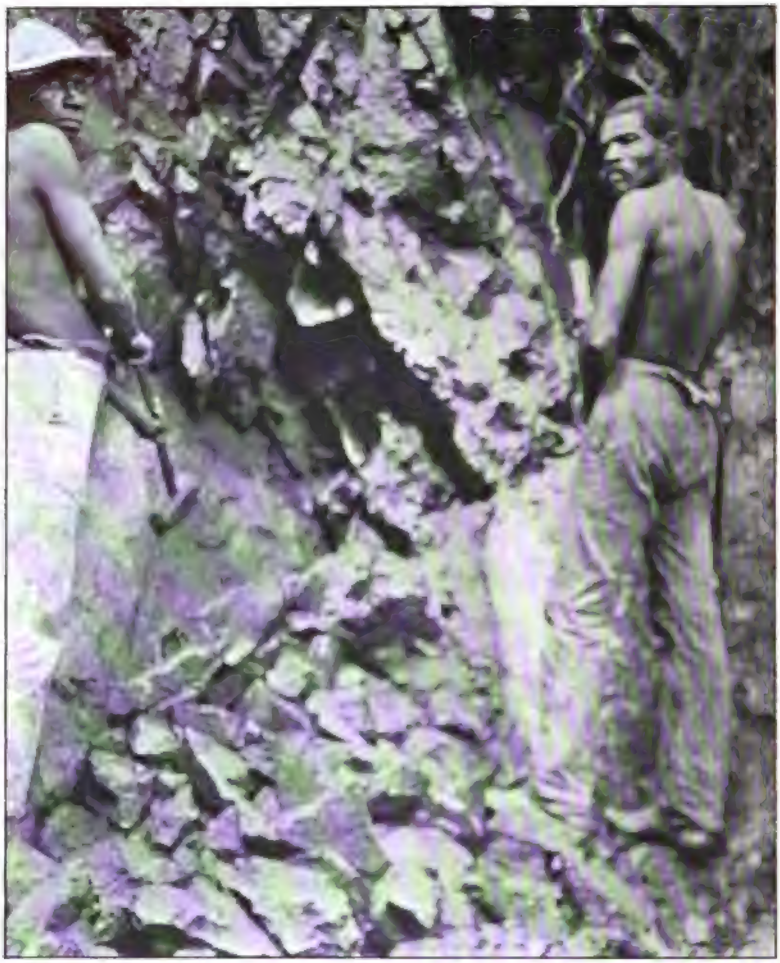
between 0.85 to 0.95. In the upper reaches of the rivers, and especially in the small streams, the gold is coarse, nuggets of considerable size being sometimes found.

Since the sixteenth century, a few or no attempts of a serious or well-directed character have been made to operate these gold-bearing gravels. One or two quartz mining operations were begun some few years ago, but they appear to have been either badly managed, or, what is most probable, no gold-bearing quartz ore bodies of sufficient size and richness were found that would pay. The reasons for the abandonment of the gold-washing operations by the Spaniards in the sixteenth century can be easily understood; human nature was then much the same as now, and these adventurers, hearing of the riches of Mexico and Peru, abandoned Santo Domingo for supposed new and better fields. In other words, Santo Domingo, in common with the other West India islands, then began to experience the vicissitudes of a constantly advancing frontier. The strength of Spain was spent in attempts to find gold and acquire the whole continent of America. Her failure was utter and absolute in the face of the stronger and more practical Englishmen, and her measure of success is shown to-day by the impress her language, customs, and civilization has left upon the Spanish-American republics of South America.

Besides gold, the great basic batholiths in some parts of the island show indubitable evidences of the presence of considerable quantities of copper. During the old Spanish regime these indications appear to have attracted little or no attention, and it was not until about the year 1850 that any attempts were made to explore the island for copper ore.

It was either then, or a year or two later, that an Englishman of wealth, by the name of T. S. Heneken, undertook the work in a serious and intelligent manner. In the vicinity of the Nigua and Jaina rivers in the province of San Christobal, on the south side of the island, numerous drifts, cuts, and shafts in hard rock attest this man's perseverance. His results were either discouraging or else it was his untimely death that put a stop to the work. In those days a copper ore that could be extracted and smelted at a profit would now be considered very rich; from

GOLD-BEARING GRAVELS IN JAINA RIVER



NATIVES BREAKING COPPER ORE OUT OF HARD ROCK ON THE SIDE OF BOCARA HILL

my own intimate acquaintance with the region in which Mr. Heneken operated, I am disposed to think he did not find much copper ore rich enough to pay with the relatively primitive mining and smelting methods of the period. But he evidently did encounter considerable quantities of comparatively lean ore that would now be regarded as highly desirable.

The operations that have been carried on within the past eighteen months, with the view of exploring these copper deposits upon the upper Nigua river, have shown considerable ore bodies of great scientific interest and possibly of much commercial value. They are contained both in fissures in the diorite-porphyry of the district and in mineralized areas of the similar rock close to its contact with the limestones, which have been assumed to be, though not positively identified, as Cretaceous. Limestone in contact with a basic eruptive are often, in other countries, the receptacles for the deposition of great bodies of copper ore, and such may prove to be the case in Santo Domingo.

Without entering into a technical

discussion, it may be said that, reasoning from analogy, there is warrant for the belief they will here also prove copper-bearing. Some of the copper ore in the veins now being explored is very rich, running as high as 30 per cent. copper and from $1 to $5 per ton in gold and silver. The ores are chiefly chalcopyrite and bornite. No chalcocite has yet been found in quantity, but the probabilities are that this extremely desirable mineral may yet be encountered.

It is an interesting fact that Santo Domingo is one of the few places in the world where amber occurs in any considerable quantities. As is well known, the bulk of the supply used in the arts comes from the neighbourhood of Konigsberg, on the Baltic sea coast. There it occurs in the lower Oligocene, and appears to have been deposited originally in glauconitic beds of a clayey nature, which was afterward eroded by wave action and the amber distributed, though much of it is taken from beds in which it was originally entombed.

Amber is simply fossillized rosin, derived apparently from certain coniferous trees. The conditions under which it occurs in Santo Domingo do not appear to differ substantially from those on the Baltic sea coast. It is found near Santiago City, associated with lignite, sandstones and conglomerates. These beds probably belong to the Oligocene formation, and are found containing amber at a number of places on the north coast, as well as on both flanks of the Monte Cristi range. It also frequently occurs in the streams flowing through these beds. The amber is usually in ovate lumps, ranging from the size of a pea to a man's fist, often flattened, dull on the exterior, being covered with a kind of brownish crust. None of these deposits have been studied scientifically, although several abortive attempts have been made to operate them for commercial purposes. The whole subject is matter worthy of thorough investigation, for there is reason to believe that these deposits may be of value.

In the vicinity of Bani, on the south coast, rock salt (Halite) occurs in apparently large quantities. The beds are in Tertiary rocks, probably of the Pliocene. It has been mined in a small way from time to time for domestic purposes. Near Azua, which is not far from Bani, petroleum occurs in quantity. Some wells have been drilled, but as yet do not appear to have yielded very satisfactory results. Native sulphur is also reported as occurring in this district. It is to be expected that the Tertiary formations of this island, as in other parts of the West Indies, may yield petroleum, bitumen, salt, sulphur, and gypsum. Practically no explorations have yet been made in a careful or scientific manner; hence it is not safe to draw any further conclusions one way or another in regard to their presence or absence in Santo Domingo.

About all the ores and valuable minerals known to the active imagination of the promoter are stated to occur in Santo Domingo. With the exception of iron, and possibly some argentiferous galena, it is unlikely that any valuable ores or natural mineral products will be found, excepting those already mentioned. The unknown always appeals to the imagination, and as so much of this large island is unexplored, even in a geographical sense, there is plenty of room for indulging in this form of pastime.

Lignite coal occurs in a number of localities throughout the island. It is usually in thin seams, but at some places these appear of sufficient size to be workable. Undoubtedly these beds may be of some value, especially in view of the remarkable economies now being achieved with gas engines, and the satisfactory results already obtained by the generation of gas from lignite and its subsequent use in gas engines.

Iron ores, both magnetite and hematite, are found near Cotui on

A NATIVE HUT MADE OF SPLIT BAMBOO

the northern side of the great mountain complex known as the Cibao. These deposits have not been carefully investigated, but from the meagre knowledge at our disposal, they do not appear to be valuable, being neither extensive or rich. It must not be assumed from this, however, that iron ore bodies of both large extent and good quality may not occur on the island. Great and valuable iron ore deposits are now being worked in the eastern part of Cuba, where similar geological conditions obtain, and if analogies are of any value, one might be justified in considering them in this case.

But however great the mineral sources of Santo Domingo may be, and we have seen they are likely to be considerable, they can never become but a fraction of the value of her agricultural products. The vegetable growths of this island do not differ much from those of the other countries in the same latitude, but the soil of Santo Domingo has not been exhausted by centuries of cultivation, as has that in some of the other West India islands.

Furthermore, the great extent of varied elevation gives the mountainous section of the island a rather wide range of temperature, with a consequent flora of both the tropic and temperate zones. The sugarcane lands are said to be exceptionally productive. The average of the Macoris district is about ten annual cuttings before replanting,—that is,

the cane when planted produces ten crops. The cacao (which is the basis of cocoa and chocolate) is claimed to possess exceptional quality, and to bring unusually high prices, especially in Germany. In tobacco culture the Dominicans are not successful; no doubt the fault lies in the preparation and treatment of the leaf, for there appears to be no sound reason why equally as good tobacco should not be grown in Santo Domingo as in Cuba.

Again, banana growing is not as successful there as on the Central American coast, probably owing to some difference in climate. Cotton and sisal are among the neglected products for the culture of which the island presents peculiar and unlimited opportunities. Santo Domingo coffee is excellent, the mountainous character of the land being especially well adapted for its cultivation. In timber and tropical woods, Santo Domingo is especially rich. The rugged and uninhabitable character of the country and an almost absolute lack of roads suitable for vehicular traffic have prevented the cutting of the great forests that clothe its hill and mountain sides. The mahogany of Santo Domingo is claimed to be, and probably is, the best in the world. There appears to be an abundance of it. Lignum-vitæ, satinwood, and cedar are relatively common, and among the mountains pine is plentiful in some localities. Of the dye woods, logwood and fustic are largely exported; in a word, the timber resources of Santo Domingo far exceed those of all the other West India islands combined.

Cattle, and especially goats, thrive throughout the island. Hogs run wild. They are of the type built for speed, and known in America as "razorbacks." Like the pigs, the horses and mules are probably the descendants of the original Spanish stock brought over at the time of Columbus, and, lacking care and breeding, have greatly degenerated.

STARTING A DRIFT ON A COPPER VEIN AT SAN FRANCISCO HILL ON THE NIGUA RIVER

The horses and mules are small and scrubby, but when given decent care, become tough and hardy.

The fauna of Santo Domingo is remarkable for its lack of variety, especially with the mammalia, the largest indigenous representative of which is the agouti, a little animal about the size of a rabbit, but allied to the guinea pig. Of late years the mongoose was introduced to destroy rats, but is likely to become a nuisance here, as elsewhere. There is plenty of bird life, although apparently there are not many varieties.

The reptilia are represented by numerous lizards, snakes, and a few crocodiles in certain remote swampy places. Snakes are rather numerous, but, as in all the other greater Antillean islands, are not poisonous. Insect life is, of course, plentiful; but the supposed comparative scarcity of the yellow fever mosquito is notable, and probably accounts for the rarity of this disease in Santo Domingo, for, other things being equal, the conditions are quite as favourable here for its propagation and spread as in other parts of the West Indies and Southern United States. The malaria mosquito is common, and, of course, the disease is ever present in localities favourable for the insect. In the mountainous district, however, all mosquitos are practically absent. The fisheries of the island are said to be capable of great development, but as to this the writer has no personal knowledge.

Unlike Jamaica and even Porto Rico, Santo Domingo is absolutely without good roads, and this lack of means of communication has probably much to do with the political unrest that has been so prevalent upon the island. There are two short railways, one from Sanchez, at the head of Samana Bay to La Vega, a distance of seventy miles, operated by a Scotch company, and the other from Puerto Plata, on the north coast to Santiago, the largest of the interior towns. This latter road is forty-five miles long, and was originally built by Belgians. The steep grades over the Monte Cristi range of mountains are overcome by a cog and rack system, which has been a source of constant expense and trouble to the American company now operating the road. In other respects this railway appears to have been badly designed by the Belgians, but these faults are now being remedied by the present more efficient management.

Santo Domingo is a magnificently watered country. The trade winds that come from the vast expanse of the South Atlantic blow with a steady, regular current across the island. Impinging upon its high mountains, their moisture is precipitated upon the densely forested slopes, which, acting as reservoirs, retain the moisture and regulate, as far as possible in a tropical climate, the flow or run off to feed the innumerable streams that develop into several quite large rivers running approximately east and west, parallel to the mountain chains, and also the many smaller rivers flowing directly from the mountains to the sea in a general north and south direction.

Such a vast network of streams in a rugged country of this kind produces many waterfalls and rapids and affords opportunities for the generation of water-power that it would possibly be difficult to excel, could the irregularities of flow that are characteristic of most tropical streams be controlled. Assuming this to be possible, the power to be derived from such a source is practically unlimited, and as the distances of electrical transmission would never be very great, as compared with similar systems elsewhere, the whole island could be provided with cheap electric power sufficient for its future needs. One of the greatest difficulties to railway construction in a rough country would be thus overcome, and roads that could never pay with the use of steam power might be profitable with the use of electricity.

ENTRANCE TO THE OLD CATHEDRAL IN SANTO DOMINGO CITY

At present the greatest need of Santo Domingo is undoubtedly good roads of some description. Good roads are a natural corollary to good government. In this case it may be said in truth that, given a system of good roads, the people would insist upon a good government. Staple government means prosperity, which all the Dominicans need and want.

It is almost impossible to believe how difficult the mere struggle for existence appears to be in this enormous rich and fertile island. The cry is now often for bread, as it was also in the old Spanish time. Then all the energies of the Spaniards were directed toward the production of gold, whilst food was brought from Spain. Now, no gold is produced and often very little food, little or no advantage being apparently taken of the natural bounty of the tropics. It is difficult to conceive such a condition, but the fact remains that the people are often half starved. Probably no country in the world has ever had a worse government, and at present there is no prospect of much betterment. Unaided, these people cannot achieve for themselves anything better.

It has been the habit of newspaper writers and others who have visited Santo Domingo to speak rather disparagingly of its people, who are naturally, and especially at the present critical period, very sensitive upon the subject. From my own experiences with the Dominicans, I

am disposed to think they are at times unfairly judged. The better sides of their national character cannot be determined from those one is most likely to meet in the seaboard towns and trading centres. Neither do the government officials, as a rule, commend themselves favourably to ideals elsewhere. But even in this class, there are many excellent men. As in Russia and China, the morals of the individual suffer by the corrupt system of which he is a part. Spain never founded a politically wholesome colony, and it is too much to expect these people of themselves to do any better in self government.

Though a mixed race, I believe the Dominicans are the best of the West India natives. Daily intercourse with them and their employment in large numbers has given me a high opinion of the Dominican "man with a hoe." Absolutely illiterate, and in some respects primitive as a savage, he is naturally intelligent, peaceable, and hard-working. As is usual among mountaineers, there is good character here, and upon its development the future prosperity of the country will depend. What these people need and ask for is the cessation of political disturbances, and to be let alone to earn their living. As is usual with races other than those of Anglo-Saxon stock, they lack the power of organization. The germ of the "town moot" is not in them; a stronger race must lead and govern them, else they revert to absolute savagery. At present the government is republican in name only, a government of the people, by the politicians for the politicians, and as such has become intolerable.

The exact population of Santo Domingo is not known, but is estimated to be between 300,000 to 500,000, the former figure being probably nearer the truth than the latter. Hayti is said to possess about a million inhabitants. The proportion of negro blood there is much greater than in Santo Domingo. The strain of Indian or Carib blood is very distinct in some of the Dominicans, and the people, as a whole, are by no means homogeneous. Isolation of communities by reason of the rough topography of the country has had a tendency to racial segregation, and in some sections the people are nearly white, whilst in others the pure African type is predominant.

Rough labour is good, the average wage being about fifty cents a day for about twelve hours, with a siesta at noon. Skilled labour is rather inferior, but proportionately very well paid. The climate is thoroughly healthy to white men of temperate and sober habits, being in this respect quite equal, if not superior, to that of Cuba. In the mountainous interior there are practically no mosquitos; consequently, fever is rare, and, on the whole, it is doubtful if a healthier country of equal area is to be found anywhere within the tropics.

I believe it cannot be assumed that the educated Dominicans regard the present conditions of the island and government with any degree of satisfaction. Some may temporarily profit by it, but, on the whole, I think they are too intelligent to feel otherwise than disgusted and mortified with the present state of affairs. A few years ago the world did not know Santo Domingo, and heard very little about it. For many years it has been a social and political derelict, stranded amid the blue waters of the Caribbean Sea. To-day, on the contrary, the island is the focus of a rapidly developing interest.

ELECTRICAL MACHINERY FOR MINES

SAFEGUARDS AGAINST FIRE AND EXPLOSION

By George Farmer, M. Inst. M. E., C. C. M.

THE modern mining engineer, whilst striving at the practical adaptation of electricity to every kind of work in and about the mines under his charge, has come face to face with one feature in its use which demands careful attention. He has found that electric power transmission offers many advantages for mining operations which no other power can offer, but he has been forced to yield to the fact that it is also dangerous, to some extent, in mines which are subject to discharges of explosive gases.

It has been said that the conditions existing in underground work of any description are just those that point to the adoption of electricity as the medium par excellence for transmitting power. When the mining engineer looks at the problem of how best to transmit power from the surface through a deep shaft to the point below ground where his machinery may be situated, he finds that whatever means are resorted to, there must be a loss in this transmission. With compressed air or steam a large percentage of the power is wasted in leakage at joints, etc., and with the latter condensation, too, is an important factor.

If electricity is chosen, there is much less loss than in other forms of power transmission. Thus for long distances it is imperative, if the transmission is to be economically effected,—and economy may be all the profit in a mine,—that either the voltage shall be high, or the size of the wire shall be large to allow of a low voltage. The latter alternative is employed only in exceptional cases, as the first cost of a long line of heavy copper conductor would be almost prohibitive. In practice it has been found that about 500 or 600 volts is the highest pressure at which it is wise to work underground. At higher pressures there is great liability of sparking at the commutators, and the results of an accidental shock to an employee are always serious and often fatal.

Although electric power transmission offers so many advantages for mining operations that its use is a constantly growing one, it nevertheless carries with it the danger of ignition of fire-damp and air mixtures from sparks and arcs which are apt to occur. Fire-damp (carburetted hydrogen) and air become explosive when mixed in the proportion of 1 part of fire-damp to 6 parts of air, or 16.6 per cent. of fire-damp, the mixture reaching its worst explosive point when in the proportion of 1 part of fire-damp to 9.5 parts of air, or 10.5 per cent. of fire-damp in the air. Of course, we are reminded that such a quantity should never be allowed. In the ordinary run of things, such a quantity would not be found, but in the case of a sudden diminution of atmospheric pressure, in a sudden slowing-down of the air current, or in the case of a sudden outburst of gas (fire-damp), such as sometimes occurs, such a

quantity might be suddenly brought on to any machine working in its path. It is generally the unexpected that happens, and the unexpected may always be knocking at our doors under the fickle conditions of a mine.

The writer has had many years' experience in mining, and is a strong advocate of electric power transmission; but, nevertheless, he considers that its use should be attended with the strictest care, and that foresight should be exercised before putting down an electric plant.

Prevention of ignition of mine gases from electric machinery has been made the subject of exhaustive experimental investigations in Great Britain and in Germany. That the sparks produced by a breaking cable, and the sparking sometimes resulting from the commutator, are capable of igniting mixtures of firedamp and air has been too clearly proved in more than one instance. This danger formed much of the subject matter of the British commission appointed to investigate the dangers of electricity underground, and suggestions and rules were made with the view of preventing it. Such rules are certainly very good, but it is always found that good common sense is worth more than rules, and that rules are of no value unless common sense is attached to the enforcing of them.

The subject was studied in Prussia by a special commission as long ago as 1885. In 1890 a series of investigations were made on behalf of the French Government. In quite recent years, in Belgium, in Germany, and in Great Britain, investigations, searching and exhaustive, have been made by eminent specialists. The appliances subjected to test included direct and alternating-current motors, starters, resistances, switches, transformers, etc., under conditions as nearly as possible like those met in actual service. Experimental galleries were used, so constructed that they could be filled with highly explosive mixtures of gas and air, in order that the appliances should be subjected to the worst dangers apt to be found in mines.

The dangers from electric machinery underground lie principally in the possibility of sparking and consequent ignition of a gaseous and explosive atmosphere. In several cases it has been clearly proved by such demonstrations that the explosive mixture would fire. In the case of direct-current machines the special points of danger have been found to be the brushes and the commutator. In the case of alternating-current machines such points of danger have been found to lie at the collecting rings and brushes. In addition to the dangers from sparking at the point of collection of the current, there are others associated with electric machines of every class and type. Excessive heating in the windings may cause the burning-out of insulation and the production of flame, whilst accidental breaking of a cable or wire also may lead to the production of flame and arcs.

How are such dangers to be remedied? It is practically impossible to prevent the outflow of gas or the accumulation of dust to any great extent. The Coal Mines Regulation Acts tell us to dilute noxious gases and make them harmless, but this does not prevent the gas being given off, and the gas may not be diluted quickly enough to accomplish the desired object. It is evident, therefore, that while we dilute the gases as much as possible, some other prevention must be resorted to. The gases and dust must be brought under such conditions that combustion cannot take place. If electrical machinery is used, it must be so constructed and worked under such conditions that firing of gas or dust cannot occur. On more than one occasion fires have originated from electrical machinery, faulty, perhaps, but still the electric machinery more often gets the blame than does the fault itself which has been so emphatically revealed. No one other

than a mining man can really imagine the anxiety which attends the dreaded evil fire, which, once started, may suddenly destroy hundreds of lives. This is evidenced by the deplorable fact that many explosions, at which many lives have been lost, have been traced back to fire as an origin, with gas or dust, or both, as feeders.

Two methods, in general, have been employed by electrical engineers to prevent fire and explosion by the working of motors. The first method aims to prevent the access of gas to any parts of the motor likely to produce sparks, thus making ignition impossible. The second method is to enclose the motor in such a manner that any flame, due to the ignition of gas within the enclosure, shall not be able to ignite gas in the outer atmosphere. This latter method is a copy of the principle of the miner's safety lamp.

In the first method it is usual to enclose the commutators, brushes, and adjacent parts in a chamber filled with oil, this acting as a protection against access of gas and at the same time as an insulator. In the second method the motor is enclosed in a case provided with openings for the circulation of air, these openings being protected with coverings of iron wire gauze. The gauze is made of such a size, preferably 28×28, or 784 apertures to the square inch, that gas within the casing, even if it should ignite there, cannot pass its flame to the air outside.

Although experiments have been made with motors of both types, it has been shown that absolute safety cannot be secured with either method. The fault lies more with the user of the motor than the maker. The conditions under which the sparking or heating of motors will explode fire-damp must depend, in the first instance, upon the intensity and duration of the spark, and in the second place upon the overload on the motor, its liability to vibration, and other causes. It has been found that faulty adjustments, vibration of the brushes, fouling of the slip rings with coal dust or oil can result in dangerous sparking, even when the motor is running under a uniform load; to these must be added the dangers of burning, or heating in consequence of an overload, and also the possibility of mechanical injury to the insulation.

The writer has had under observation electric motors which were never known to give the slightest sparking or trouble so long as they were kept perfectly clean, properly adjusted, not subject to vibration, and not overloaded; but when the same motors, for the purposes of experiment, were allowed to get dirty, suffer from faulty adjustments, vibration, and temporary overload, sparks were often seen increasing in intensity and duration as the faults grew worse.

Whilst mining engineers must welcome any good object lesson in the application of science to their industry, they must give the lesson its full scope of justice. The question of danger from electric motors is more than ordinarily applicable to their consideration, and is one specially worthy of careful consideration. As mining becomes deeper, owing to the exhaustion of present-day seams of coal, it will become imperative to mining engineers to fully consider this question before designing or fixing electric light plant, because as mines become deeper they will be more subject to outflows of gas.

By experiments it has been found practically impossible, in a really practical sense, to use a motor which is entirely enclosed, for the reason that gas has been found to gradually enter during severe tests with the most carefully enclosed motors, and by the ignition of the mixture the cover has been blown off and the vicinity exposed to danger. Even with a motor enclosed in a casing in which openings were covered with wire gauze, sparks have caused the gas to ignite, and the heat thus pro-

duced has either caused the gauze to become red hot, or else small carbonaceous particles adhering to the gauze became incandescent to an extent sufficient to ignite the gases outside.

The same thing happens, of course, to a safety lamp, and the Royal Commission of 1886 contended that a "safety" lamp was a safety lamp no longer when surrounded by an explosive mixture, if it continued to burn the gases. The same thing must be said of the electric motor,—that it is no longer safe when it becomes surrounded by an explosive mixture of gas and air, and although the mining engineer may keep a sufficient amount of air circulating through his mine, to dilute and render harmless all noxious gases under ordinary conditions, yet he is not aware of, nor has he any means of preventing, an "outburst" of gas, which might envelop the motor in an instant. His motor, to be safe at all, must be placed under such conditions as will ensure its not sparking. Whilst casings, after either the first or second methods, may be used as an extra safeguard, the real guard, the only true preventive, is care and foresight.

From experience, the writer is able to give the following notes of advice, which should be exercised in addition to above:—

Plant all motors on good solid beds, so that vibration will be reduced to a minimum. For haulage or pumping purposes never place the motor on girders which are supported only at the ends. It happens very often that the motor is slung on girders as a platform over the ordinary traffic road. For coal-cutting purposes see that the machine road is well laid and solid.

Keep all motors clean and free from dust and superfluous oil. Remember, the pit is not as clean as your office, and that machines in the pit require more than an occasional dusting. The dust should be constantly blown out by a pair of bellows.

Don't put down over-estimated machines; they are an inevitable source of nuisance and danger,—cheap in first cost, perhaps, but enormously costly afterwards.

Badly designed machines are dangerous and ought to be emphatically avoided. They do not even look well.

If you desire to work with electric power, avoid so-called cheapness; put down plant which is a little over the work required for it to do, nicely designed on a solid bed, so that defective adjustment and severe vibrations are not parts of its character, and see that the machine is kept perfectly clean. Make your machine to suit the conditions of the mine; at the same time make the conditions of the mine as easy and safe as possible for the machine.

LOCOMOTIVE CRANES

By Percy R. Allen

The present article is supplemental in a way to the one on the same subject printed in this magazine in November, 1906. It deals exclusively, however, with locomotive cranes of British and Continental make, while the earlier one concerned itself with American designs.—The Editor.

THE term locomotive crane, used in a broad sense, may be taken to include not only jib cranes, but overhead travellers and the long-span gantry cranes now extensively used in shipyards, coal storage depots and quarries, but the space available for this article does not permit of any general description of these latter varieties, although they present many interesting mechanical features.

Rude forms of cranes mounted on a truck or bogie that could be pushed about from place to place are to be found described in several mechanical works published towards the end of the eighteenth century, but the writer is not aware who was the first person to use a steam engine to make the carriage of the crane self-propelling, as well as to effect the lifting, derricking, and slewing operations; but to whomsoever the invention may be due, there is no doubt the locomotive crane has now become indispensable wherever material in bulk is to be handled.

A locomotive crane need not necessarily run upon a railway track; indeed, it is sometimes an advantage that it should be able to travel elsewhere. Several of the leading builders of road locomotives and traction engines arrange to fit jib cranes to the smoke-box end of their boilers when desired, and an example of this kind is illustrated in Fig. 1, which shows one of Aveling & Porter's road locomotives with a swivelling jib crane mounted over the fore carriage. It will be seen that the drum to which the lifting chain is attached is mounted on the jib itself, so that there is no difference in the lead of the chain whatever the position of the jib may be. The drum is driven by double-reduction gearing from a horizontal shaft geared at the other end of the crankshaft of the engine, and the slewing motion is obtained from a worm and wormwheel arrangement just below the upper bearing of the upright of the jib, while the friction brake for controlling the lowering of the load can be seen directly underneath the large bevel wheel. No extra attendant is required to manipulate the crane, as the motions are all worked from the foot-plate by the same man who controls the driving and steering of the traction engine.

Obviously a machine of this kind can be conveniently employed for many purposes, such as loading and unloading wagons in railway sidings or to convey materials to and from barges and lighters alongside wharves, as the fact that the jib can be slewed through half a revolution, that it can be turned at right angles either way to the centre of the boiler, makes it possible to work parallel with a line of railway wagons in a depot, or to lift in and out of barges on either side of a narrow wharf. Traction engines fitted with cranes of this description have, of late years, been extensively used in connection with military operations, and in the late Boer war proved very useful not only for haulage, but for handling the field artillery.

Another form of self-propelled crane, also independent of a track, is shown in Fig. 2. This is built by Messrs. Taylor & Hubbard, of Lei-

FIG. 1.—A ROAD LOCOMOTIVE SLEWING CRANE, MADE BY MESSRS. AVELING & PORTER, LTD., ROCHESTER, KENT

cester, and was originally designed for use in steel foundries for picking up castings of points and crossings and conveying them to the place where the lay-out was being assembled on a flat floor. These cranes are built to lift up to two tons at 15 feet radius, and the whole crane can be made to revolve through a complete circle on the carriage, which is fitted with broad-tired wheels without flanges. The larger pair of wheels is geared to the engine, while the front pair can be controlled or steered in just the same way as a motor car. All the motions connected with the crane are controlled by the one driver on the platform. No attempt has been made in designing this crane to make it perform the functions of an ordinary traction engine, but the power it possesses of being able to pick its way through a crowded yard gives it a distinct sphere of usefulness.

Cranes combined with locomotives find important uses in railway working, both in connection with breakdowns and also for handling freight in large depots and places where goods have to be transshipped. A rather peculiar form of locomotive crane is illustrated in Figs. 3 and 4. This is built by Messrs. Hawthorn, Leslie & Co., of the Forth Bank Works, at Newcastle-on-Tyne, the special feature of the arrangement being that the load is lifted by the direct action of steam on the jib itself without the interposition of any gearing. This is effected by mounting a steam cylinder near the fulcrum of the jib and making the piston rod lift the jib direct. The turntable on which the jib and lifting cylinder are mounted can be turned in either direction through a complete circle by means of an independent two-cylinder turning engine, and the turning, lifting, and lowering are controlled by the driver on the foot-plate. The size of the

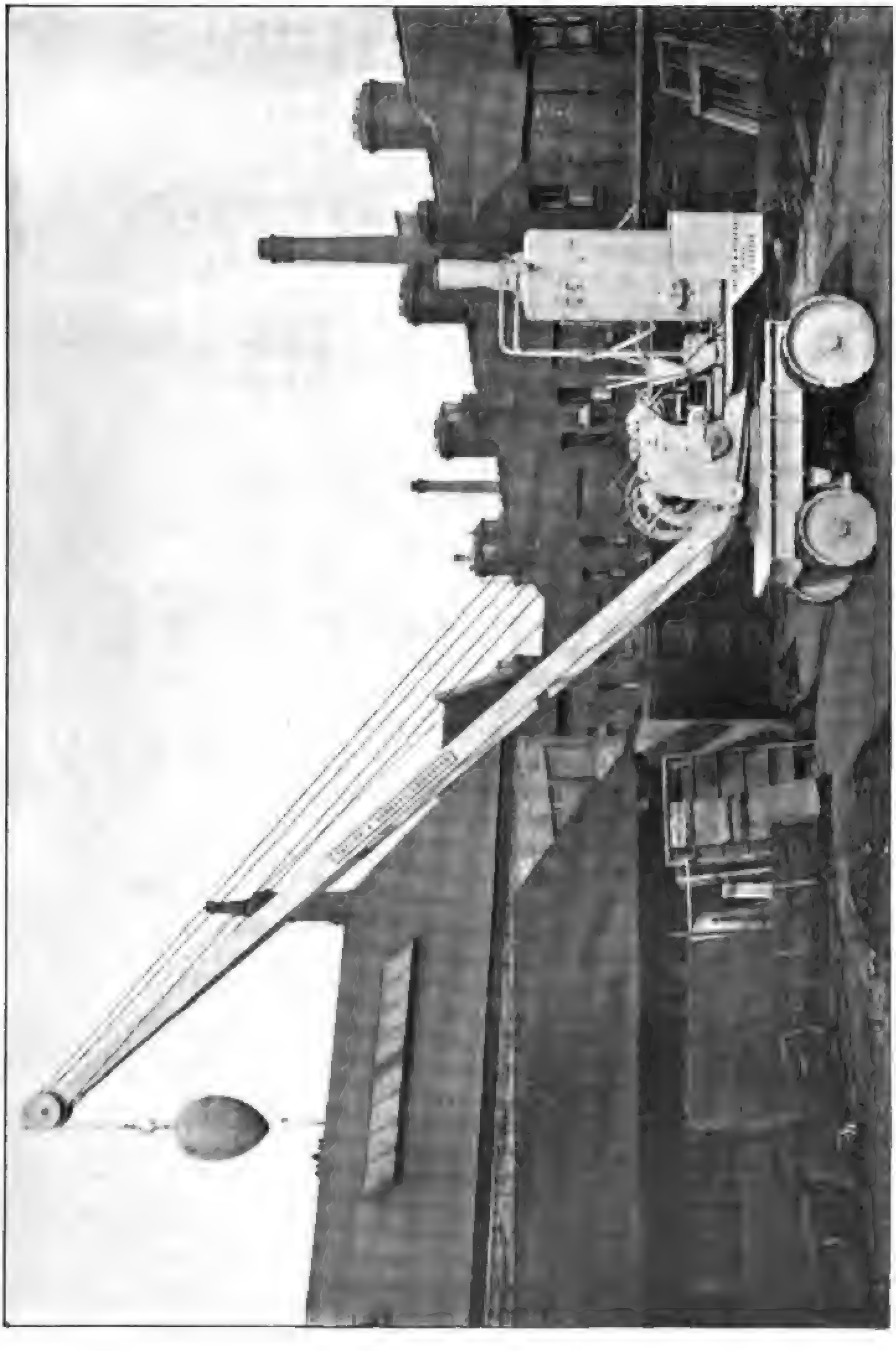
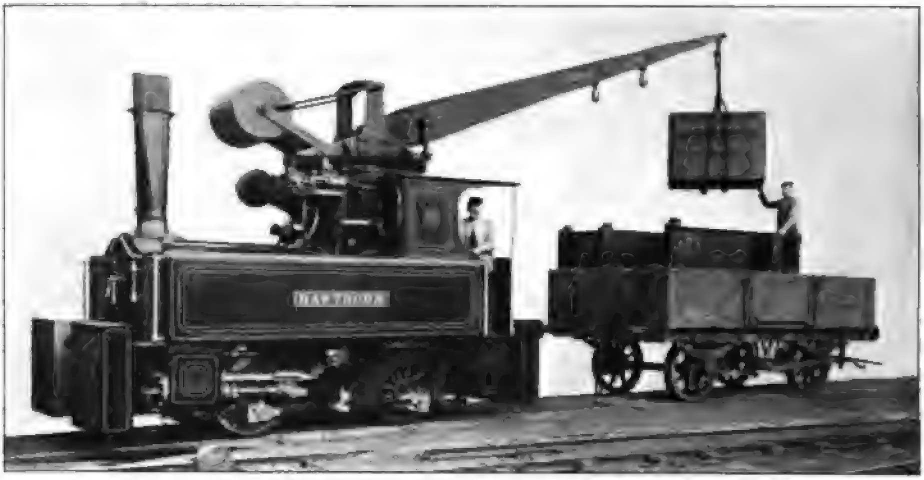


FIG. 2.—SELF-PROPELLED CRANE, INDEPENDENT OF A TRACK, BUILT BY MESSRS. TAYLOR & HUBBARD, LEICESTER



FIGS. 3 AND 4.—CRANE MADE BY MESSRS. R. & W. HAWTHORN, LESLIE & CO., LTD., NEWCASTLE-ON-TYNE

lifting cylinder is so proportioned that, with normal steam pressure, two tons can be lifted at a distance of 20 feet from the centre of the railway track; three tons at 16 feet; and four tons at 12 feet. The crane is mounted upon what is in other respects an ordinary locomotive of the usual gauge, and which can be used like any other locomotive for shunting and marshalling wagons. A considerable number of these cranes have been built, and have been found very useful in iron and steel works, as their rapidity of action makes them valuable for handling materials that have to be dealt with while hot.

Coming now to the class of cranes used on railways, in connection with breakdown work and the removal of wreckage after accidents, it will be found that several conditions have to be met that are not easy to provide for in one machine. In the first place, the crane must be a powerful one, with all the parts proportioned for what may be termed a considerable overload capacity, as in the removal of tangled wreckage after an accident all sorts of slips

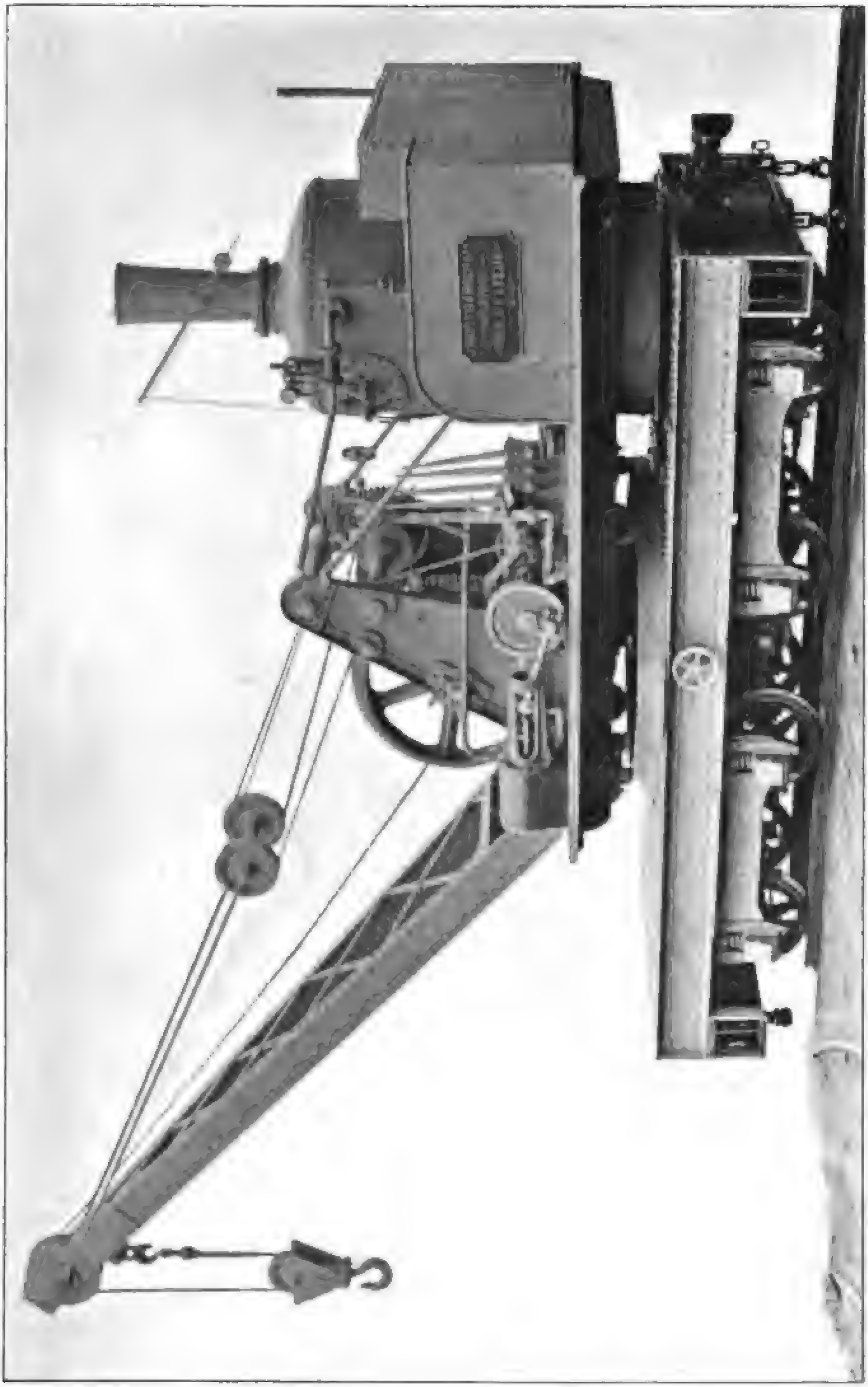


FIG. 5.—A BREAKDOWN LOCOMOTIVE CRANE, BUILT BY MESSRS. J. BOOTH & BROTHERS, LTD., RODLEY, LEEDS

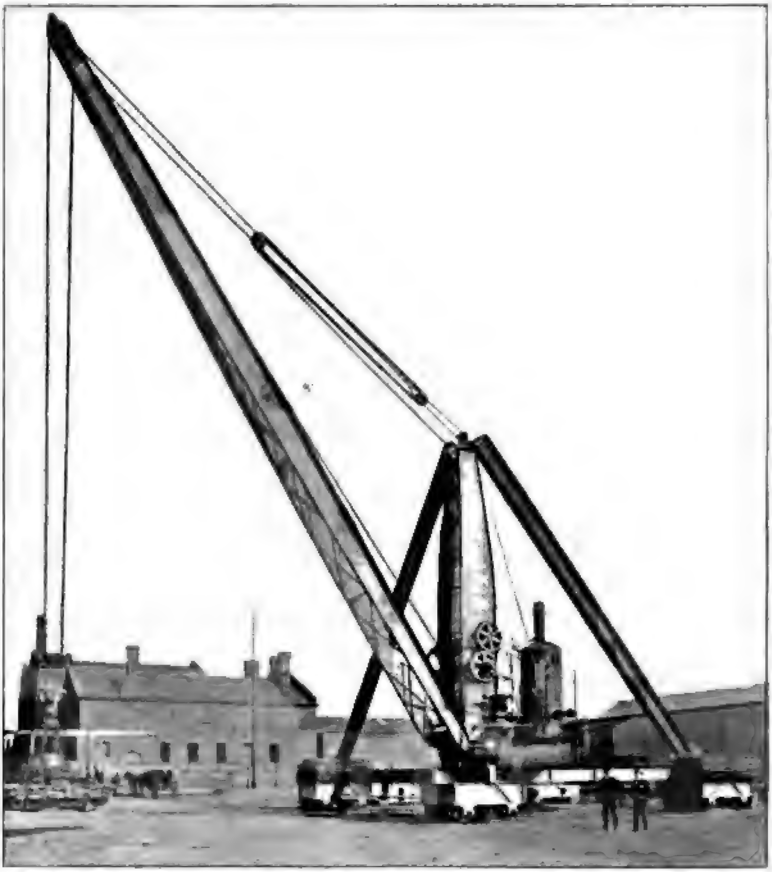


FIG. 6.—A 20-TON DERRICK CRANE, BUILT FOR THE DOVER HARBOUR WORKS BY MESSRS. JOHN H. WILSON & CO., LTD., LIVERPOOL

take place, and the weight to be lifted may be five tons at one moment and twice as much the next. The gearing must be strong; the boiler must be capable of carrying a high pressure, raising steam quickly, and working with any water that can be procured on the spot; and lastly, the carriage on which the lifting portion is mounted has to combine the construction of an easy-running vehicle, so that it can be rapidly transported to the scene of operations, with a solid construction and anchorage facilities to enable it to deal with the maximum load.

These conditions are not easy to combine even on the normal gauge of 4 feet 8½ inches, and on a narrower gauge it becomes still more difficult. Therefore, the crane shown in Fig. 5 is rather interesting, as illustrating what can be done in this way. This was built by Messrs. Joseph Booth & Bros., Ltd., of Rodley, to the order of the Crown agents of the Colony of Lagos. The gauge of the line is 3 feet 6 inches. The crane proper is mounted on a steel carriage, and provision is made for steel girders to form an extended base when the crane is not in operation. This is in addition to the usual clips for clamping down to the rails. The side frames of the lifting crab are steel plates, stiffened with steel angles. The carriage is also entirely of steel. The working pres-

sure of the boiler is 80 pounds; the cylinders are $9\frac{1}{2}$ inches in diameter with 12-inch stroke. The jib is 20 feet long, supported by rods and steel wire ropes, and lifts the full load with block. The height of the whole arrangement had to be kept down to a loading gauge of 12 feet 6 inches.

Travellers who, during the past few years, have been in the habit of crossing the English Channel by Dover, will probably recognize the crane shown in Fig. 6 as being one of a pair in use on the eastern extension of the breakwater, while a similar one is in use on the other side of the harbour on the prolongation of the Admiralty Pier. These the Scotch crane type, having a long jib, connected to a centre post, which is prevented from overturning by means of two diagonal back legs attached to a common centre at the top of the vertical post, and having the other ends anchored to the ground or to a platform.

Stationary cranes of this kind can be seen perched high upon wooden scaffolds almost everywhere where building operations are going on, but they are not usually built as self-moving machines. However, in the case of the cranes at Dover, the whole machine has quite a considerable range of movement, both in a transverse and a longitudinal direction. The three points of the triangle

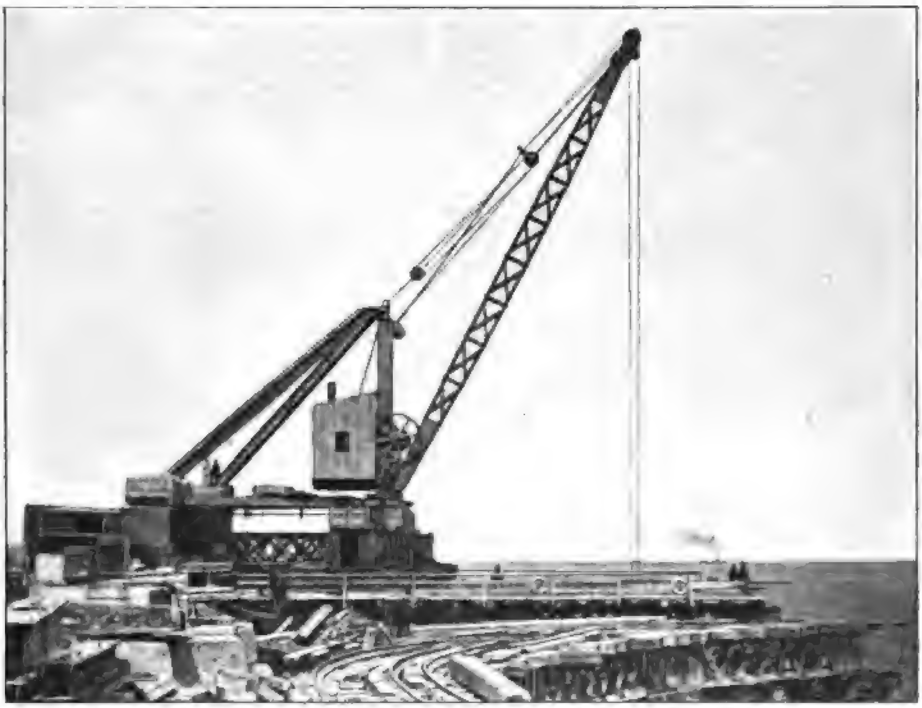


FIG. 7.—A DERRICK CRANE, SIMILAR TO THE ONE SHOWN OPPOSITE, SUPPLIED BY THE SAME BUILDER FOR THE BUENOS AYRES HARBOUR WORKS

cranes were made specially for the contractors, Messrs. S. Pearson & Son, Ltd., by the firm of John H. Wilson & Co., Ltd., of Liverpool, and belong to what is usually termed forming the base of the structure are very securely held together, and each end rests on an eight-wheel bogie running on two tracks of ordinary 4-foot $8\frac{1}{2}$-inch gauge, spaced 38 feet

apart, on the top of a travelling bridge of 100 feet span. One pair of wheels on each of the two back bogies and a corresponding pair on the front bogie under the engine are geared together, so that they all move simultaneously in either direction and thus avoid any tendency for racking of the framework.

One pair of engines, with cylinders 12 inches in diameter by 12 inches stroke, work the lifting, derricking, slewing, and traversing motions of the crane on the bridge and also the longitudinal movement of the bridge itself. This latter motion is effected by an arrangement of long, square shaft geared to the travelling wheels at each end of the bridge, and deriving motion from the engine by a square sleeve and gears placed on the front bogie.

The full capacity of the crane is 20 tons at 70 feet radius, and, with double gear, it will lift this at the rate of 14 feet a minute, while if the load is reduced to three tons, it can be lifted at the rate of 100 feet a minute; the derricking motion of the jib is effected simultaneously with the lowering of the load, and as the jib moves up at the same time, one motion to a great extent balances the other.

To the casual observer, the action appears a kind of mechanical paradox, as, while the lifting rope is unwound, the weight appears to hardly descend. The boiler supplying steam to the engine is of the usual vertical type with cross-tubes, and works at 80 pounds pressure. The total weight of the crane in working order is 120 tons, and 30 tons of ballast are required on each of the back bogies to insure the necessary stability.

A view of another similar crane taken from a different position is shown in Fig. 7, which represents one built by the same makers for the Buenos Ayres harbour works. This crane differs in some respects

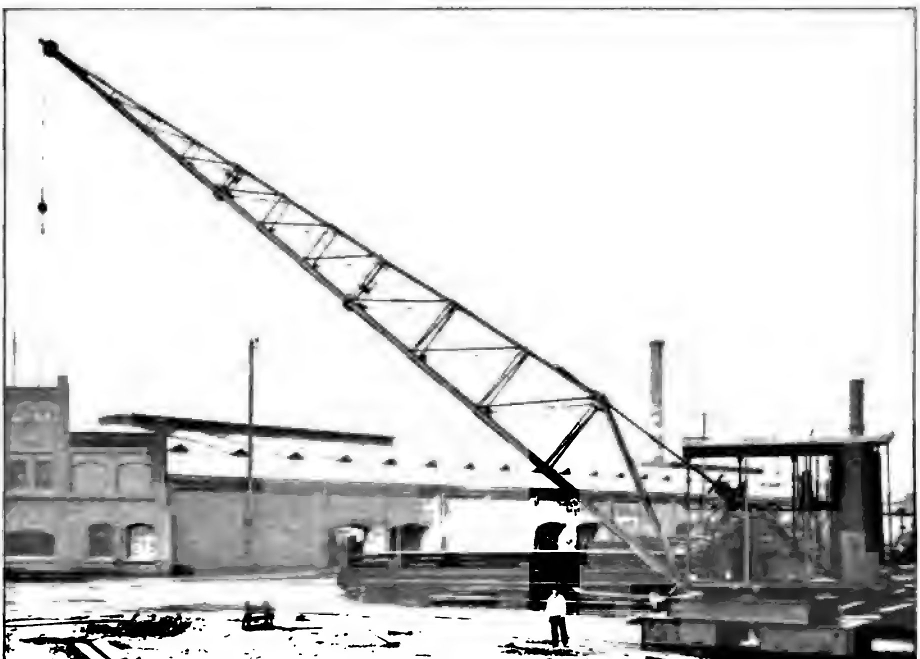


FIG. 8.—TRAVELLING REVOLVING STEAM CRANE, BUILT BY MESSRS. BEECHAM & KEETMAN, DUISBURG, GERMANY

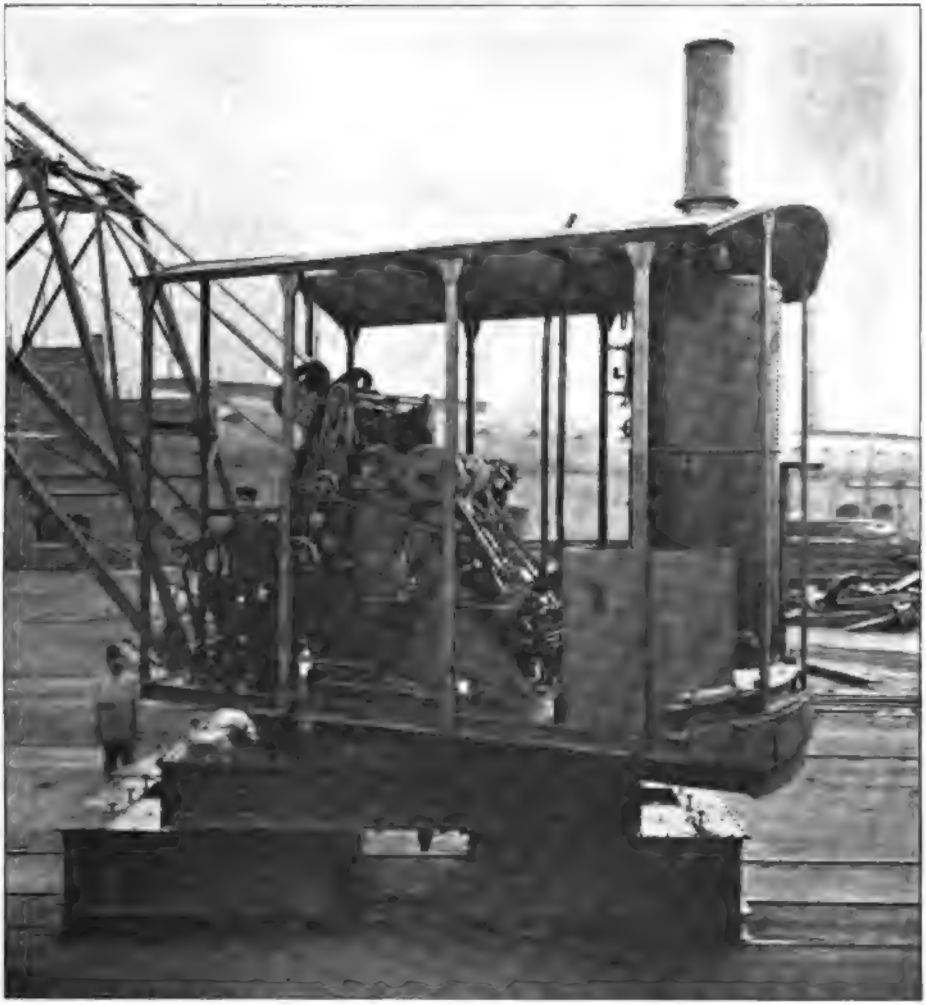


FIG. 9.—ANOTHER VIEW OF THE CRANE OPPOSITE

from those used at Dover, but the illustration brings out clearly the arrangement of the bogies on the track. A crane of this type is a very powerful machine, and to be able to lift and swing a block of concrete 20 tons in weight at a radius of 70 feet means a good deal in submarine work.

The science of crane building has been developed by Continental constructors just as much as it has in Great Britain; indeed, some of the cranes erected in recent years at the German shipyards are amongst the largest in the world. The most powerful of these shipbuilding cranes are, of course, those used for masting purposes and lifting in the engines and boilers, but long-reach locomotive cranes are also used to a considerable extent. Through the courtesy of Mr. August Reichwald, of London, the British representative of Messrs. Beecham & Keetman, of Duisburg, the writer is enabled to show, in Figs. 8 and 9, a locomotive crane which has been built by this firm, with an abnormally long jib capable of lifting about 1½ tons

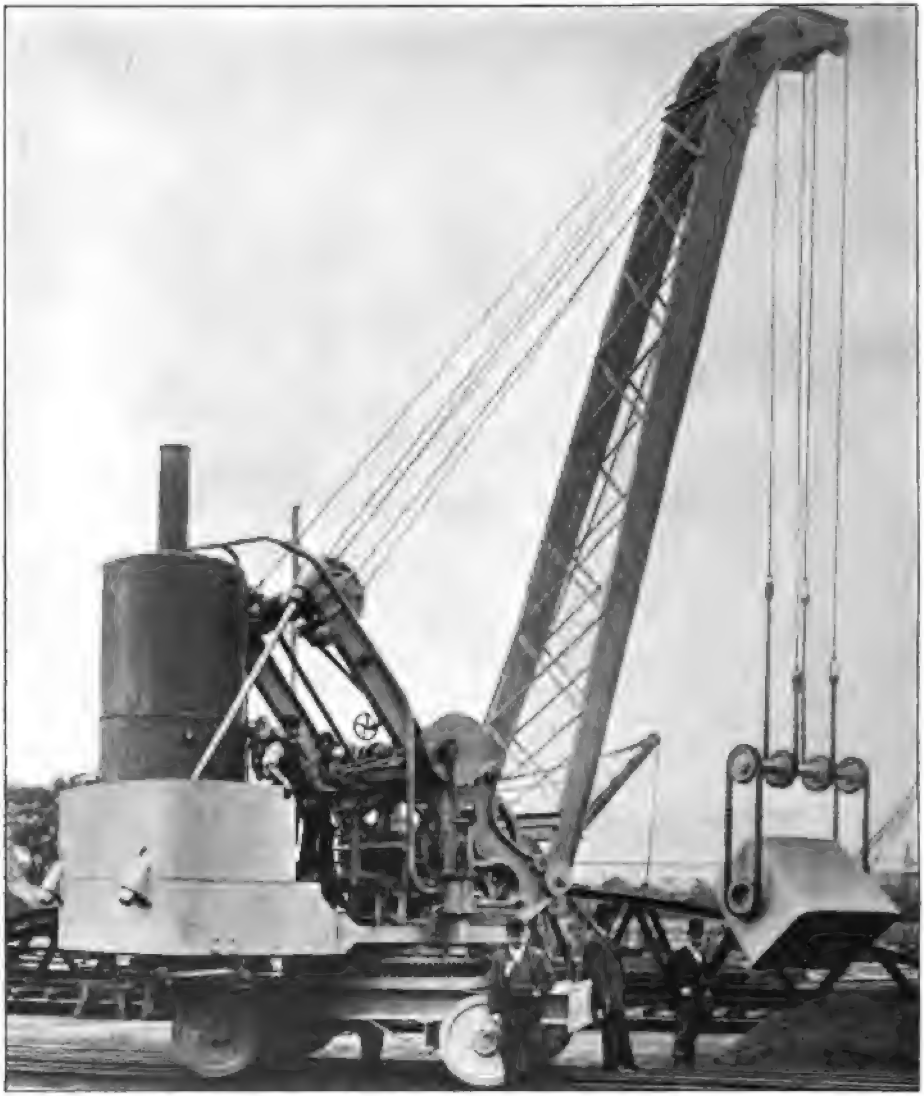


FIG. 10.—STONEY'S TIPPING CRANE, BUILT BY MESSRS. RANSOMES & RAPIER, LTD., IPSWICH

at a maximum radius of 86 feet and a load of 3 tons at a radius of 44 feet 4 inches. As there is a bridge spanning a part of the works through which the crane has to pass from time to time, arrangements had to be made so that the jib can be lowered nearly into the horizontal plane.

The crane works on a rail track of 2 meters gauge, approximately 6 feet 6 inches, and owing to the compensating arrangements for four out of the eight supporting wheels, the carriage can easily pass around a curve of 46 feet measured from the centre of the track. All the motions are driven from a two-cylinder engine. The friction brake for lowering is fixed on the extended shaft of the lifting drum, and the lowering is controlled in the ordinary course of events entirely by this brake. The

lifting is done by a steel wire rope; the load of 3 tons can be lifted at a speed of 98 feet a minute, while the speed of travelling is 82 feet a minute. A complete revolution and a half of the crane can be made in one minute. A crane of this sort is a very useful appliance to have in a shipyard, particularly during the construction of the lower part of a vessel's hull.

Fig. 10 shows another form of locomotive crane, which also has a jib rather longer than the usual practice. This is Stoney's patent tipping crane, built by Messrs. Ransomes & Rapier, of Ipswich, and was primarily designed for dealing with material which could be conveniently handled in boxes or skips, and is extensively used for small coal, flint chippings, sand and gravel, and for discharging the semi-fluid material brought up by dredgers. The Manchester Ship Canal Company have nine of these cranes constantly at work discharging the output of the dredgers in service in the several canal sections between Eastham and Manchester.

A general idea of the action of the crane can be obtained from the illustration. The steel boxes, each of which holds 6 tons of spoil, are placed close together on a barge and brought successively under the delivery chute of the dredger. As soon as they are full, the barge is towed away and brought under one of the Stoney cranes, and the boxes are picked up, one by one, and the contents tipped either into railway wagons or down a chute on to a spoil bank.

It will be seen that on each side of the box is fixed a kind of trunnion having sprocket teeth on it, and that these trunnions hang in the loops of two pitch chains passing over sprocket wheels on the lifting bar of the crane. The load is lifted by four steel wire ropes wound in pairs on two barrels, these barrels being driven by a variable mechanism under the control of the driver. When the ropes are all wound or unwound at the same rate the box is simply lifted or lowered without any tilting action, but, by imparting a relative motion to the ropes, the lifting bar carrying the sprocket wheels can be made to turn in either direction and the box discharged in any position within the range of the lift; moreover, this tilting can be performed at any rate desired, and this is a very convenient feature of the arrangement, as when dealing with sloppy material from the dredger the box may be first slightly tilted to drain the water off back into the river and then it can be slewed over the spoil bank and turned over to complete the discharge.

The crane illustrated is built for a working load of 10 tons, and the total height of lift is 35 feet, the jib having a variable radius of from 16 to 25 feet. The total weight of the complete crane in working order is about 50 tons, and the carriage is constructed so that it can work either on a line of 4 feet 8½ inches gauge, or 9 feet gauge when occasion demands. The writer has had many opportunities of watching the operations of these cranes on the Manchester Ship Canal, and can testify as to their capabilities for rapidly handling both the full and empty boxes. As many as 312 of these boxes, each containing 6 tons, have been lifted from barges to a height of 25 feet, swung around, tipped, and replaced empty on the barge in a working day of nine and one-half hours, and this with one crane. This time also included the changing of the barges.

The daily increasing use of electric transmission has naturally led makers of steam cranes to modify their designs so that electric motors can be substituted for steam engines, and now that almost every manufacturing establishment has the electric current laid on, the use of electric cranes is often attended with marked economy. Both alternating

and continuous current can be used to supply the motors, but continuous current seems to be generally preferred as having some advantages in the way of starting and stopping and easy control. In designing a self-propelled electric crane care must be taken to arrange the conductors so that they do not interfere with any of the necessary movements of the crane or get foul of the load whilst it is being lifted.

In the electric crane shown in Fig. 11, made by Messrs. Craven Bros., of Manchester, any possible difficulty of this kind has been got over by placing the conductors in an insulated cable, one end of which can be plugged into any of a series of junction boxes, let into the ground so that the cover of the box is flush with the surface, while the other end of the cable is connected to the controller by rubbing contacts on a cable drum at the end of the carriage. This drum is capable of carrying 200 feet of cable, and as the crane approaches or recedes from the junction box, so the cable is either wound on or unwound from the drum, the action being the same as in the case of the gathering wheels used in some of the electric locomotives employed in mining work.

Two electric motors are provided, one to perform the slewing and travelling motions and the other for working the hoisting barrel. The section motion shaft for working the barrel is provided with the maker's patent automatic coil brake, which can be seen in the illustration just underneath the brake wheel, and, besides this, the hoisting motion is also fitted with a mechanical foot-brake arrangement for lowering by gravity. The load of this crane is nominally 2 tons, but it is capable

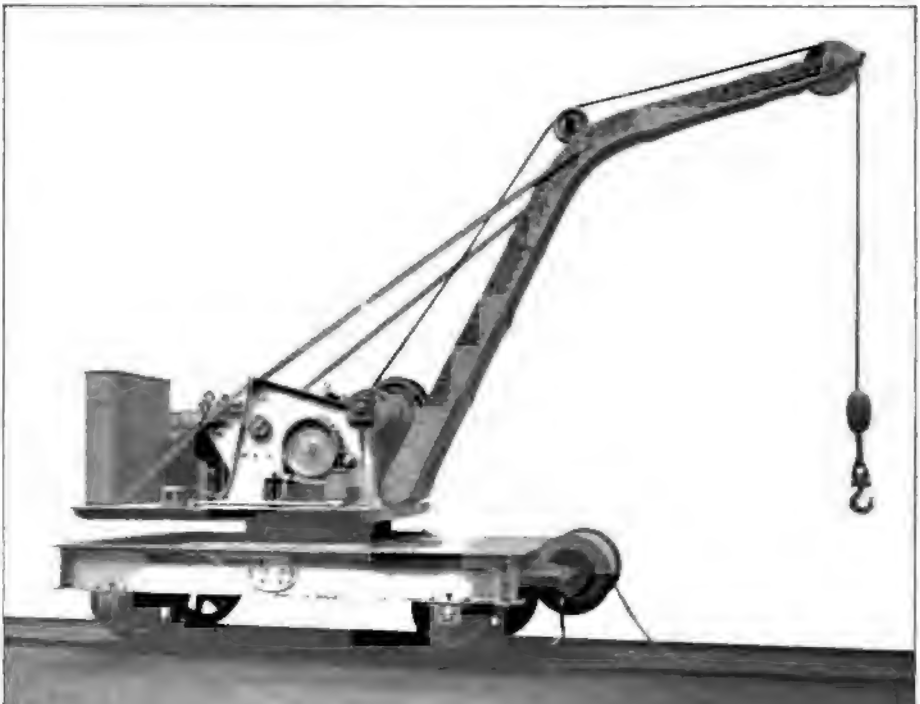


FIG. 11.—AN ELECTRIC LOCOMOTIVE CRANE, BUILT BY MESSRS. CRAVEN BROTHERS, LTD., MANCHESTER

FIG. 12.—AN ELECTRIC CRANE, BUILT BY THOMAS SMITH & SONS, RODLEY, LEEDS

of taking 25 per cent. overload. There are two sets of travelling wheels, one being ordinary flanged railway wheels, 2 feet 9½ inches diameter, running on a railway track of 3 feet 6 inches gauge. The other set of wheels are flangeless and adapted to work on a 6-foot smooth track when required. The wheel base of both sets of wheels is 10 feet, and the maximum width of the carriage is 6 feet 9 inches.

Fig. 12 shows another electric locomotive crane which has the peculiarity of having all the motions driven by one single-phase, alternating motor of 20 B. H. P., of the totally enclosed type. It is rather unusual to find in Great Britain single-phase motors applied to this pur-

FIG. 13.—THIRTY-TON CRANE, BUILT FOR THE PORTSMOUTH DOCKYARD BY MESSRS. JOHN H. WILSON & CO., LTD., LIVERPOOL

pose, but the writer is assured that in this case it is perfectly satisfactory, and the gearing is just as much under control as if a continuous-current motor were used. The current is collected from a central cable, which can be seen in the illustration stretched on insulators in the centre of the track, while the return is made by the rails themselves, as in tramway work. The hoisting motion is by single-purchase spur gearing and a single friction clutch with a special design of expanding rings and wedges. The wrought steel lattice jib is 48 feet long, and will lift 5 tons at 16 feet, 2 tons at 35 feet, $1\frac{1}{2}$ tons at 40 feet, and 1 ton at 42 feet radius, and the track is 7 feet gauge.

The illustration shows the crane as it is at work at the Hammersmith Lighting Station and Wharf on the

banks of the Thames. It was constructed by Messrs. Smith & Sons, of Rodley, specially with a view to utilize the single-phase alternating system which was already available at the station. As already mentioned, this crane has only one motor for all of the motions, but the majority of electric locomotive cranes are fitted with two motors, and in some cases with three motors, one for lifting the load and for derricking or adjusting the jib, one for the slewing, and the other for propelling. Where three motors are used, the motor for the slewing motion is generally made the smallest of the three, the others being of about equal size.

The dimensions and lifting capacities of locomotive jib cranes have been steadily increased year by year, and some of those now employed in harbour works and by bridge and shipbuilders have a range of lift and dead-weight capacity that would have been deemed impossible ten years ago. Compared with overhead travellers, they are less expensive to install, as no permanent overhead erection is necessary, and as the track upon which a locomotive crane operates can be laid down almost anywhere. A self-moving jib crane can be caused to work over a wide area, while the range of the traveller is limited to the width of the gantry and length of the longitudinal run.

On the other hand, in such places as foundries, erecting shops, and the like, overhead travellers will generally be found preferable to jib cranes, as they enable the floor space to be kept clear, and the direct lift obtained from a crab on an overhead traveller enables greater weights to be lifted than would be possible with a jib crane of any ordinary dimensions. Moreover, the direct suspension of the load enables the latter to be more precisely controlled,—a point of much importance in foundries and erecting shops.

TESTS OF A GAS ENGINE

OPERATED BY A SUCTION PRODUCER

By George H. Barrus

AS few data have been published showing the performance of gas engines operated with suction producers using anthracite coal, to which so much attention is now being given by engineers and power users, the time is opportune to present the following account of some recent tests made by the writer on a plant of this kind:—

In its principal features the plant consisted of a three-cylinder, vertical gas engine rated at 100 H. P., and a suction producer made by Messrs. R. D. Wood & Co., of Philadelphia. The load on the engine was a Prony brake, surrounding a water-cooled wheel on the engine shaft, the plant being one used for experimental purposes.

In one respect, the tests are of unusual interest, as they show a remarkable effect caused by using over again in the producer a part of the inert gases discharged by the exhaust of the engine, substituting them for the steam generally used. It was for the purpose of determining the character of this effect that the tests were primarily undertaken.

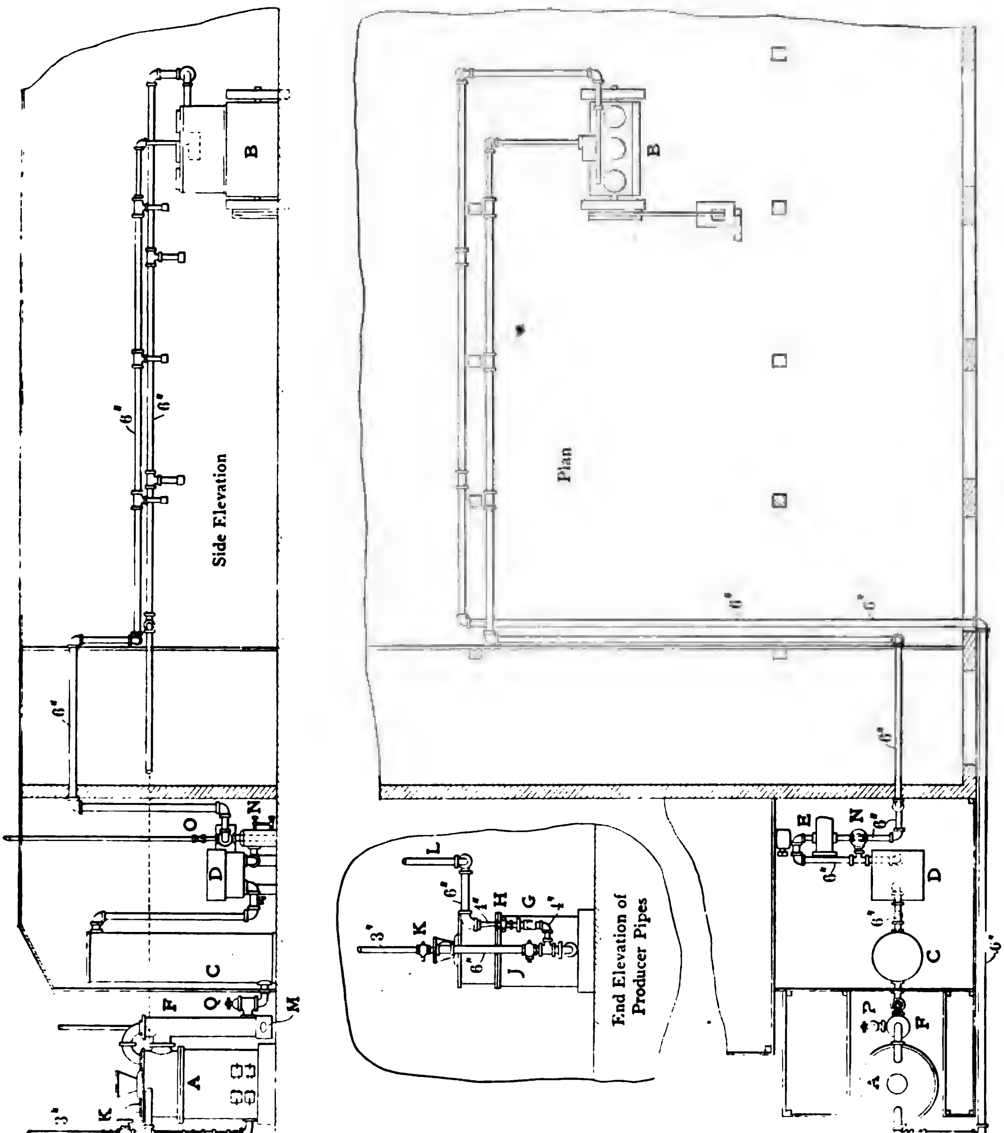
DESCRIPTION OF PLANT

The leading elements which make up the plant embrace the producer proper, a pre-heater or evaporator, a scrubber, a purifier, a starting blower, and the engine. The relative location and arrangement of these component parts is shown in outline on the next page. The producer proper *A* is set in the open air, about 100 feet distant from the engine. The length of the pipe through which the gas passes from one to the other, including the passages in the various intermediate apparatus, is about 150 feet. On leaving the top of the producer, the gas enters the upper part of the pre-heater *F*. Descending to the lower part of this, it enters the bottom of the scrubber *C*. Passing through the scrubber and emerging at the top, it descends through a long vertical pipe and enters the under side of the purifier *D*.

From this point, it goes to a small tank *N*, or to the blower *E*, according as the blower is running or not and the tank discharge pipe is sealed with water, and finally enters the main supply pipe, proceeding thence to the engine *B*.

The exhaust from the engine is piped back to a point near the producer, where it escapes through a vent *L* to the atmosphere, and a branch pipe near the vent is connected to the ash pit of the producer. Details showing the connections between the exhaust pipe and the producer are given in the end elevation.

When the exhaust gases were used in the producer, the fresh air supply entered the ash pit through the 4-inch valve *G*, which was carried wide open. The exhaust gases entered the pit through the 4-inch valve *H*, which was adjusted so as to be from two-thirds open to wide-open. The 6-inch valve *J* was closed, and the 3-inch vent valve *K* was wide open, thereby allowing the steam generated in the jacket space surrounding the



GENERAL ARRANGEMENT OF SUCTION PRODUCER PLANT

upper part of the producer to escape to the air.

When the ordinary system was in operation, the fresh air supply entered the bottom of the pre-heater at *M* and passed upward through the heater. Thence it went through the water-jacket space covering the upper part of the producer, where it mixed with the steam or vapour there formed, and finally passed down through the 6-inch pipe and 6-inch valve *J*, which was wide open, and entered the ash pit. The vent *K* and the valves *G* and *H* were closed.

Referring to the producer itself, this apparatus consists of a vertical cylindrical iron chamber, embracing three principal compartments. The lowest compartment is the ash pit. The next is the furnace, which is 42 inches in diameter and about 4 feet high. The bottom is provided with a circular grate 30 inches in diameter, having about 50 per cent. air space, arranged in ⅝-inch openings. The furnace is lined with fire-brick.

The upper compartment, which may be regarded as a continuation of the middle one, is an annular gas chamber, lined with fire-brick, which receives the gases given off from the coal below. It is surrounded and covered with a water-jacket by which the gases are cooled. Within the gas chamber is a central coal magazine, 20 inches in diameter, and this is surmounted at the very top of the producer by a hopper, forming the receptacle into which the coal is first charged.

The hopper is provided at the bottom with a dumping valve, opening downward, and at the top with a cover opening upward. Both are worked by counterweighted levers, and the latter is clamped tight by means of a screw operated by hand.

There are four doors opening into the furnace compartment just above the grate. These give access to the bottom of the coal bed for the purpose of cleaning the fire. There are also four ash-pit doors. All these doors have clamps held by screws, for making them tight. Poke holes are provided in the cover of the upper chamber and in that of the magazine, and these are closed by perforated iron balls held by clamps. The water-jacket surrounding the upper part of the producer is connected by a 1-inch pipe with the jacket-space surrounding the pre-heater, and the water supplied to one serves for both. This water is evaporated, and the steam which is formed collects in the upper part of the space above the water-line.

The scrubber, which is a vertical chamber, 4 feet in diameter and 15 feet high, filled with coke, is supplied with a spray of water, which, after circulating through the coke, goes to the sewer and carries away the impurities of the gas.

The engine is one operating on the four-cycle system. The speed is controlled by a throttling governor, which regulates the quantity of gas and air admitted after passing the mixing valves. When running with the ordinary system, the clearance in the cylinders was that corresponding to the usual proportions employed by the builders, such as to produce about 140 pounds compression pressure. When the exhaust gases were used in the producer, the clearance was reduced by attaching special cylinder heads, which extended into the bore of the cylinders a distance of 1 inch (the face of the standard head being flush), thereby increasing the compression to the neighbourhood of 200 pounds. Incidentally, the mechanism operating the igniters was changed from the direct-connected system operated by cams, which is usually employed, to magnetically operated igniters. The cylinders and heads were provided with the usual arrangement of water-cooled jackets, and there was, in addition, a jacket surrounding the exhaust pipe manifold. The jacket water escaped to the sewer.

The reason for changing the clearance of the engine when using the

exhaust gases in the producer will be best understood by considering the effect which they have on the composition of the original gas. The principal combustible elements which the gas contains when steam is used in the producer are carbonic oxide and hydrogen. The effect of shutting off the steam is to remove most of the hydrogen, and leave carbonic oxide alone as the leading combustible element of the product. (See Tables III. and IV.) The substitution of a part of the exhaust gases in place of the steam, it should be said, has the same cooling effect on the fire, and the same effect in preventing fusion of the ash and the formation of clinkers, as the steam has, and is a necessary condition for the continuous operation of the producer without it.

The presence of hydrogen in the gas stands in the way of securing more than a limited degree of compression in the engine cylinders. When that limit is passed, the hydrogen is ignited by the heat formed during compression, and the objectionable features known as "back-firing" and "pre-ignition" occur. With carbonic oxide alone as the principal combustible element, the engine is enabled to carry a much higher degree of compression, and thereby produce a proportionately greater amount of power. Consequently, on the tests using exhaust gases, the clearance in the engine was reduced so as to obtain the benefit which might follow the increased compression due to that change. No experiments were made to see if the best point of compression was reached, but all the indications seem to be that a further increase would have resulted beneficially.

THE TESTS

There were two economy tests, the first being made with the exhaust gases entering the producer, and the second with the plant operated in the ordinary way, using steam. The first test was a continuous run of twenty-five and one-half hours, made up of three eight-hour periods of nominally full load, and three one-half-hour periods of half-load, during which the fire was cleaned. The second test was not a continuous run, it being impossible to operate the engine while the fire was being cleaned and air entering the cleaning doors. This test covered two periods of about six and one-half hours each with from half-load to full-load, and two periods of one-half hour each with from half-load to full-load, and two periods of one-half hour each during cleanings, the engine being shut down. An effort was made, after the second cleaning, to run a third period under load, but those in charge of the engine were unable to get it to work, although experimenting for over two hours.

The tests were in each case started after the producer had been running loaded for several hours, thereby reaching a normal condition of operation. The fire was then cleaned, the bed of coal above poked down, and the magazine refilled to the bottom of the hopper-valve. From this time on all the coal was weighed, including that required for filling not only after the first cleaning, but after

TABLE I.—LEADING DATA AND RESULTS OF ECONOMY TESTS

Conditions	Exhaust Gases Used	Ordinary System
Date of test, 1906	March 28-29	April 5-6
1. Duration, hours	25.5	14.05
2. Total time engine was running, hours	25.5	13.17
3. Maximum brake horse-power developed,	110.5	99.8
4. Minimum power developed, horse-power	50.	7.6
5. Average brake horse-power developed for entire period	102.5	78.7
6. Average brake horse-power for running period	102.5	84.1
7. Total weight of dry coal consumed, pounds	2,927.	1,988.
8. Total ash and refuse, pounds	391.	317.
9. Percentage of ash and refuse in dry coal	13.5	15.9
10. Weight of dry coal per hour, pounds	114.8	141.5
11. Dry coal consumed per brake horse-power per hour (line 5), pounds	1.12	1.8
12. Combustible consumed per brake horse-power per hour, pounds	.97	1.51

the second and third cleanings, the last cleaning occurring just before the close of the test.

The load on the engine was maintained at the desired point by adjustments of the brake, an attendant being constantly employed for this one purpose. It was kept as near as possible at the maximum point consistent with continuous operation, which point was judged by the maintenance of the working speed. The engine itself was in charge of men who were skilled in its practical operation. As the tests covered both night and day-running, two men were employed, one relieving the other.

The leading data obtained on the two main tests consisted of the weight of coal consumed, the percentage of moisture and the weight of ashes in the coal, the brake load, and the engine speed. In determining the actual weight of coal consumed, the ash and refuse withdrawn at times of cleaning and that taken from the ash pit were screened, and the weight of unconsumed coal which failed to pass through a ¼-inch mesh was deducted from that fired.

Other data consisted of the weight of water passed though the scrubber and through the engine jackets, the temperature of the supply water and that of the water leaving the scrubber and each jacket; also the force of suction in the main pipe, and the temperature of the exhaust gases near the engine. The meters which were used were subsequently calibrated, and their rate was determined. On the first test frequent gas analyses were made, both of the mixture of exhaust gases and air entering the ash pit, and of the gas supplied to the engine, using the Orsat apparatus.

A number of samples of the gas supplied to the engine were also taken and subjected to ultimate analysis. Frequent tests were made of the calorific power of the gas supplied to the engine, using the Junker gas calorimeter. During the

TABLE II.—AVERAGE RESULTS OF ANALYSES

With Orsat Apparatus and Calorimeter Tests, Using Exhaust Gases. March 28-29, 1906

Main Gas Supply to Engine

	Per Cent.
1. Carbonic acid (CO_2)	2.2
2. Oxygen (O_2)	1.3
3. Carbonic oxide (CO)	25.6
4. B. T. U. per cubic foot by gas calorimeter (high value)	103.7

Mixture of Air and Exhaust Gases Entering Producer

	Per Cent.
5. Carbonic acid (CO_2)	3.3
6. Oxygen (O_2)	18.9
7. Carbonic oxide (CO)	.1

TABLE III.—AVERAGE RESULTS OF ULTIMATE ANALYSES

Main Gas Supply to Engine, Using Exhaust Gases. March 28-29, 1906

	Per Cent.
1. Carbonic acid (CO_2)	1.8
2. Oxygen (O_2)	1.2
3. Carbonic oxide (CO)	26.2
4. Hydrogen (H_2)	.4
5. Marsh gas (CH_4)	.7
6. Nitrogen (N)	69.7
Total	100.0

TABLE IV.—AVERAGE RESULTS OF ULTIMATE ANALYSES AND CALORIMETER TESTS

Main Gas Supply to Engine. Ordinary System. Preliminary Test

	Per Cent.
1. Carbonic acid (CO_2)	5.8
2. Oxygen (O_2)	1.3
3. Carbonic oxide (CO)	19.8
4. Hydrogen (H_2)	15.1
5. Marsh gas (CH_4)	1.3
6. Nitrogen (N)	56.7
Total	100.0
7. B. T. U. per cubic foot of gas by calorimeter (high value)	136.

second test, the quantity of water evaporated in the jacket surrounding the producer and pre-heater was determined, and the temperatures were taken of the air leaving the preheater and entering the producer, and of the gases leaving the producer and entering the pre-heater.

A sample of the coal used on the first trial was subjected to a calorimeter test. That used on the second test was taken from the same pile. The coal, it should be said, was a mixture of anthracite pea and small chestnut.

To obtain some idea of the quantity of gas produced, a 300-light gas meter was attached to the supply main, and a short test was made under each system. The meter was not large enough to carry the gas required for the full load, and the trials were limited to loads of 50

TABLE V.—AVERAGE TEMPERATURES AND OTHER OBSERVATIONS, AND RECORD OF COOLING WATER

Hourly Quantities	Exhaust Gases Used	Ordinary System
Date of test, 1906	March 28-29	April 5-6
1. Water supplied to engine jackets per hour, pounds	5,355.	5,376.
2. Water supplied to exhaust manifold jacket, pounds	533.	1,230.
3. Water supplied to scrubber, pounds	2,044.	2,624.
4. Water supplied to pre-heater and producer jacket, pounds	*90.	120.
5. Average temperature of general water supply, degrees	51.	54.
6. Average temperature of water leaving cylinder jackets, degrees	115.	123.
7. Average temperature of water leaving exhaust manifold jacket, degrees	171.	134.
8. Average temperature of water leaving scrubber, degrees	122.	131.
9. Temperature of exhaust gases leaving engine, degrees	845.	830.
10. Temperature of gases leaving producer, degrees	....	665.
11. Temperature of air leaving pre-heater and entering producer, degrees	....	223.
12. Temperature of cold air supplied to producer or pre-heater, degrees	50.	56.
13. Vacuum in the main supply pipe, inches	3.6	3.9

* Estimated.

TABLE VI.—HEAT BALANCE

	Exhaust Gases Used	Ordinary System
Date of test, 1906	March 28-29	April 5-6
1. Total heat of combustion per pound of dry coal by calorimeter, B. T. U.	12,253.	12,253.
2. Dry coal consumed per hour, pounds	114.8	141.5
3. B. T. U. supplied to plant per hour	1,406,644.	1,733,800.
4. Heat rejected per hour by producer and pre-heater jacket water evaporation, B. T. U.	101,430.	0.
5. Heat rejected per hour by scrubber water, B. T. U.	145,124.	202,048.
6. Heat rejected per hour by cylinder jacket water, B. T. U.	342,719.	370,944.
7. Heat rejected by exhaust manifold jacket water, B. T. U.	63,966.	98,400.
8. Heat converted into work, B. T. U.	267,225.	213,780.
9. Heat lost by exhaust gases, assuming that when these are used 20 per cent. of the heat is returned, B. T. U.	354,802.	459,756.
10. Heat unaccounted for, B. T. U.	131,378.	388,872.
Total	1,406,644.	1,733,800.

TABLE VII.—EFFICIENCY OF THE TWO GAS SYSTEMS, AND THAT OF AN ORDINARY STEAM PLANT OF THE SAME SIZE

	Exhaust Gases Used	Ordinary System	densing Steam Plant
1. Brake horse-power	102.5	78.7	100.
2. Coal per B. H. P. per hour, pounds	1.12	1.8	3.6
3. B. T. U. supplied to plant per hour (Line 3, Table 6)	1,402,644.	1,733,800.	4,411,080.
4. B. T. U. supplied to plant per B. H. P. per hour	13,396.	20,640.	44,111.
5. B. T. U. supplied to engine per hour	1,028,712.	1,400,374.	3,273,400.
6. B. T. U. supplied to engine per B. H. P. per hour	9,797.	16,667.	32,734.
7. B. T. U. converted into work per B. H. P. per hour	2,545.	2,545.	2,545.
8. Efficiency of whole plant (Line 7 to Line 4), per cent	19.	12.3	5.7
9. Efficiency of producer (Line 6 to Line 4), per cent	73.1	80.	74.
10. Efficiency of engine (Line 7 to Line 6), per cent	25.9	15.3	7.9

H. P. Three tests were made with each system, one at 50 brake-horse-power, one at about 25 H. P., and one at the friction load (that of the empty brake) which was about 8 H. P. The meter was not calibrated for this particular trial, but it had been verified at normal capacity not long before.

A number of short indicator tests were made with each system at various loads, this being done on a subsequent occasion, for the purpose of showing the manner in which the combustion and expansion takes place in the cylinders, and especially the operation of the two systems as regards compression, and to determine the friction of the engine.

THE RESULTS

The data and results of the tests are given in the appended tables. Table I. gives the leading data and results of the coal and power tests; Table II. gives the average results of the analyses and calorimeter tests using the Orsat apparatus, made during the first test using the exhaust gases; and Table III. gives the average results of the ultimate analyses of the samples taken from the main supply pipe of the engine on that test.

Table IV. gives the average results of ultimate analyses and calorimeter tests of gas supplied to the engine during a six-hour run with steam used in the producer in the ordinary way obtained on a preliminary trial. Table V. gives the average temperatures and other observations and the weights of water passed through the various jackets. Table VI. presents a heat balance, consisting of the calorific value of the

TABLE VIII.—LOG OF EVENTS

Exhaust Gases Used. Test of March 28-29, 1906

March 28,	12:20 P. M.	Start test after cleaning and poking. Magazine subsequently filled with coal not weighed. Load on scales 278 pounds.
	12:30 "	Increase load to 307 pounds.
	2:00 "	Poke and refill magazine.
	3:30 "	Poke and refill magazine.
	5:07 "	Poke and refill magazine.
	6:34 "	Poke and refill magazine.
	8:00 "	Reduce load to 280 pounds.
	8:20 "	Reduce load to 141 pounds.
	8:24 "	Clean.
	8:44 "	Poke and refill magazine.
	8:55 "	Increase load to 280 pounds.
	9:00 "	Increase load to 307 pounds.
	10:45 "	Reduce load to 280 pounds.
	10:50 "	Poke and refill magazine.
March 29,	12:15 A. M.	Poke and refill magazine.
	12:45 "	to 1:15. Reduce load to average 200 pounds. Leak of air through hopper valve into gas chamber.
	1:50 "	Poke and refill magazine.
	3:18 "	Poke and refill magazine.
	5:04 "	Reduce load to 141 pounds.
	5:05 "	Clean.
	5:25 "	Poke and refill magazine.
	5:25 "	Increase load to 280 pounds.
	5:55 "	Increase load to 307 pounds.
	6:35 "	Reduce load to 295 pounds.
	7:23 "	Poke and refill magazine.
	8:51 "	Poke and refill magazine.
	10:20 "	Poke and refill magazine.
	11:48 "	Poke and refill magazine.
	1:23 P. M.	Reduce load to 141 pounds.
	1:25 "	Clean.
	1:41 "	Poke.
	1:50 "	Stop test and afterwards fill magazine with weighed coal.

Ordinary System. Test of April 5-6, 1906

April 5,	2:32 P. M.	Start test after cleaning and poking, and filling magazine with coal not weighed. Engine running with 27 pounds load on scales. Blower on.
	2:38 "	Increase load to 141 pounds.
	2:51 "	Increase load to 200 pounds.
	2:53 "	Increase load to 280 pounds.
	2:55 "	Stop blower.
	3:36 "	Engine slows down, and load taken off two or three times, owing to back-firing.
	4:21 "	Poke and refill magazine.
	5:35 "	Engine slows down, and load removed several times, owing to back-firing. Adjust middle igniter.
	5:53 "	Poke and refill.
	6:17 "	Increase load to 267 pounds.
	6:38 "	Increase load to 280 pounds.
	6:42 "	Engine slows down on account of serious back-firing.
	6:43 "	Reduce load to 253 pounds.
	6:46 "	Engine slows down from serious back-firing.
	6:48 "	Engine slows down from serious back-firing.
	6:50 "	Engine slows down from serious back-firing.
	6:52 "	Reduce load to 27 pounds.
	7:39 "	Poke and refill.
	7:49 "	Increase load to 253 pounds.
	8:38 "	Engine slows down owing to back-firing.
	9:08 "	Reduce load to 27 pounds.
	9:10 "	Stop engine.
	9:10 "	Clean.
	9:31 "	Start engine with load of 27 pounds.
	9:33 "	Poke and refill.
	9:43 "	Increase load to 141 pounds.
	9:56 "	Increase load to 253 pounds.
	10:00 "	Reduce load to 226 pounds.
	10:10 "	Increase load to 253 pounds.
	11:13 "	Poke and refill.
	12:00 Midnight.	Increase load to 280 pounds.
April 6,	12:10 A. M.	Reduce load to 267 pounds.
	12:48 "	Poke and refill.
	1:10 "	Reduce load to 253 pounds.
	2:38 "	Poke and refill.
	3:30 "	Reduce load to 200 pounds.
	3:35 "	Increase load to 253 pounds.
	3:50 "	Reduce load to 227 pounds.
	3:54 "	Reduce load to 27 pounds.
	4:00 "	Poke.
	4:04 "	Engine stops without warning.
	4:06 "	Clean.
	4:27 "	Poke and refill.
	4:35 "	Try to start engine with gas, but fail. Stop test.

TABLE IX.—GAS CONSUMPTION TESTS

Date of Test, 1906 Name of System	March 30 Exhaust Gases Used		April 6 Ordinary System	
Brake Horse-Power	Gas Per Hour, Cubic Feet	Gas Per Brake Horse-Power Per Hour, Cubic Feet	Gas Per Hour, Cubic Feet	Gas Brake Brake Horse-Power Per Hour, Cubic Feet
8.2	4,932	601	4,180	510
26.	5,526	212	5,330	205
50.6	7,704	152	7,560	149

TABLE X.—INDICATOR TESTS

	Indicated H. P.	Brake H. P.	Friction H. P.
Full load.......	120.5	100.9	19.6
Half load.......	69.4	50.4	19.
Empty brake...	31.2	8.4	22.8

coal used, and the results of computations showing the quantities of heat carried away by the various water supplies, that estimated as lost in the exhaust gases, that converted into work in the cylinders, and that unaccounted for. Table VII. gives certain computations of the efficiency of the plant based on Table VI., and that of a non-condensing steam plant. Table VIII. presents a log of the times of the various events, such as starting, stopping, poking, firing, etc., arranged chronologically. Table IX. gives the data and principal results of the gas consumption tests, and Table X., the principal results of the indicator tests.

The tables speak for themselves, but attention may be specially directed to some of the leading points.

I.—MECHANICAL OPERATION

When the engine was running with the exhaust gases entering the producer, it operated continuously without a stop, even during those periods when the fires were being cleaned, each of which periods lasted from twenty to thirty-five minutes. There was never back-firing, pre-ignition, or misfiring during the entire run. On the contrary, when the ordinary system using steam was employed, it became necessary to stop the engine whenever the fire was cleaned, and it was impossible to make the test-run longer than 14.05 hours. There was frequent back-firing, pre-ignition, and misfiring, and frequent reductions in the load had to be made, due to these causes, and to irregular operation.

An examination of the records given in Table VIII. shows the comparative unreliability of the engine when the producer was running in the usual way, and the highly satisfactory character of the operating features when the exhaust gases were substituted for the steam. In the case of the latter, no steam plant could have operated with more complete success, and no more care was exercised in handling the plant than that given by the fireman and engineer to a good steam plant.

One of the noticeable things regarding the effect of using the exhaust gases was the ease experienced in putting the engine into service. There was never a hitch when the engine was started from a state of rest and state of inactivity of the producer in getting the plant promptly into operation, in putting on the full load, or in obtaining continuous and reliable service. When once in operation, no undue care was required in the adjustment of the mixer valves on the engine, which remained in the same position continuously for many hours at a time, either when cleaning was going on and a wide change of load occurred, or while the condition of the producer was undergoing changes due to poking and refilling.

Comparing a successfully operating gas engine and suction producer with a steam power plant, most engineers, and laymen as well, consider that a gas engine requires a higher order of skill and experience in the operating engineer than a steam engine whose ins and outs are universally known. With a gas plant operating as easily as this one did when using the exhaust gases, it should require no more skill in the operating force than a modern 1000-H. P. steam plant. In such hands

the producer gas engine plant operated in this way should be as reliable for continuity of operation and successful practical use as the best class of steam plants.

2.—FUEL ECONOMY COMPARED WITH THAT OF STEAM PLANTS

Referring to Table VII., the consumption of anthracite coal per brake-horse-power per hour, using the exhaust gases (1.12 pounds), is less than one-third of that used by a non-condensing steam plant of approximately the same brake-horse-power, the latter consumption being taken at 3.6 pounds per B. H. P. per hour. The probability is that a 100 H. P. gas plant would require a somewhat higher class of operating talent than the steam plant, and thus occasion a somewhat higher cost of operation. The first cost of the gas plant is also greater than that of a steam plant having the economy mentioned, involving somewhat larger fixed charges. Making allowance for all the expenses of operation, however, there is no doubt of the large economy of the gas engines of small power over the ordinary non-condensing steam plant.

When it comes to large powers, the comparison is less favourable to the gas engine, for the reason that large steam engines are run compound-condensing, and they are much more economical in coal consumption. Probably 1.5 pounds of coal are required per B. H. P. per hour in the best steam plants of large power. At the same time, larger gas plants are, no doubt, more economical than the 100-H. P. plant tested, using probably not over 1 pound of coal per brake-horse-power per hour. With these figures in view, large gas plants are likely to run on about two-thirds of the coal used by the best steam plants.

3.—EFFICIENCY OBTAINED BY USING EXHAUST GASES, AS COMPARED WITH THE USUAL SYSTEM

Referring to Table I., the consumption of coal per brake-horse-power per hour with the exhaust gases used was 1.12 pounds, and with the ordinary system, 1.8 pounds. The difference between these figures represents a coal economy amounting to 38 per cent.

A careful examination of Tables II., III., IV., VI., and VIII., makes it evident that the single combustible gas obtained by using the exhaust gases is better adapted to the production of power than the gas composed of two combustible elements (*CO* and *H*), which is generated by the ordinary system. It is also evident that the large difference in economy between the two methods of operation is due to the same cause.

4.—RELATIVE CAPACITY OBTAINED BY USING EXHAUST GASES IN PLACE OF STEAM

A most interesting point about the use of the exhaust gases was the effect on the engine capacity. The tests were made under conditions of maximum capacity, i. e., the load applied to the brake was the maximum that could be maintained without lowering the speed beyond the range of the governor. The average power developed while the engine was continuously running was 102.5 B. H. P. when the exhaust gases were used. and 84.1 B. H. P. with the ordinary system. Referring to Table VIII., the maximum load on the brake for any considerable period in the case of the former was 307 pounds, this being on continuously from 12.30 P. M. until 8 P. M., or seven and one-half hours. The maximum for any long time in the case of the ordinary system was 253 pounds, and the period lasted from 1.10 A. M. to 3.30 A. M.,—two and one-third hours. These weights represent 110.5 and 89.3 brake-horse-power, respectively. The engine capacity was, therefore, increased about 25 per cent. by substituting exhaust gases for steam in the producer.

SMALL STEAM ENGINES

By C. H. Benjamin

IN these days of high-duty steam engines in large units, direct-connected to electric generators, and distributing power over wide areas, we are apt to lose sight of the smaller units which may be just as necessary, though not so much in evidence, as their big neighbours. Formerly the small engine was used to drive single machines or groups of machines in rooms or buildings remote from the source of power, since it was found to be more economical to carry steam than to carry belt power over such long distances. For shorter distances the greater economy of the large engine outweighed the losses due to shafting transmission.

That shafting losses are much more serious than those arising from steam transmission, has been demonstrated by experiment, and it has been shown that in ordinary shops ten years ago these averaged one-half of the total power transmitted from the engine.

The general introduction of electric transmission has changed all this and has resulted in the concentration of the steam power in one or more large units capable of sending currents to motors, wherever located, with a fair degree of economy. Notwithstanding this sweeping change, it will be apparent to any one visiting a modern manufacturing establishment, that there are places where the electric motor is not convenient. This observation applies more particularly to those operations which must go on irrespective of the running of the main power plant, such as heating, ventilating, pumping, coal handling, and elevator service.

It sometimes seems more convenient and economical to rent electrical

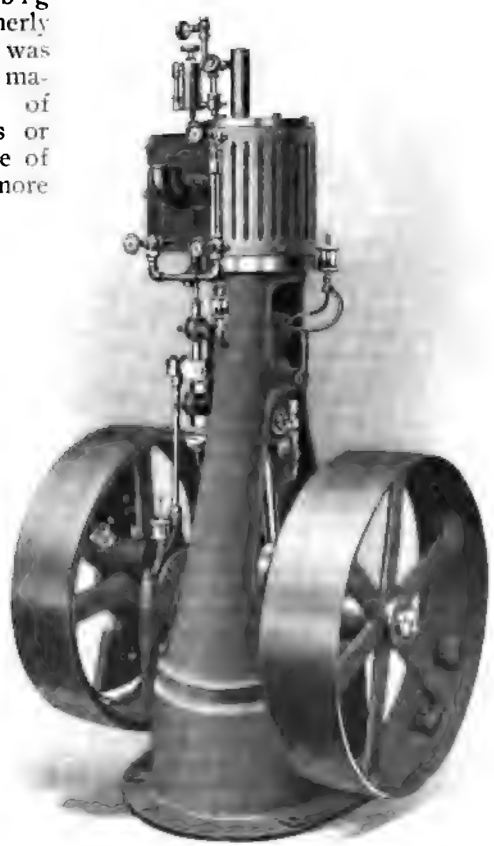


FIG. 1.—AUTOMATIC ENGINE BUILT BY THE TROY ENGINE & MACHINE CO., TROY, PA., IN SIZES FROM 4 H.-P. UPWARDS. THE 4 H. P. ENGINE HAS A 4¼" X 5" CYLINDER

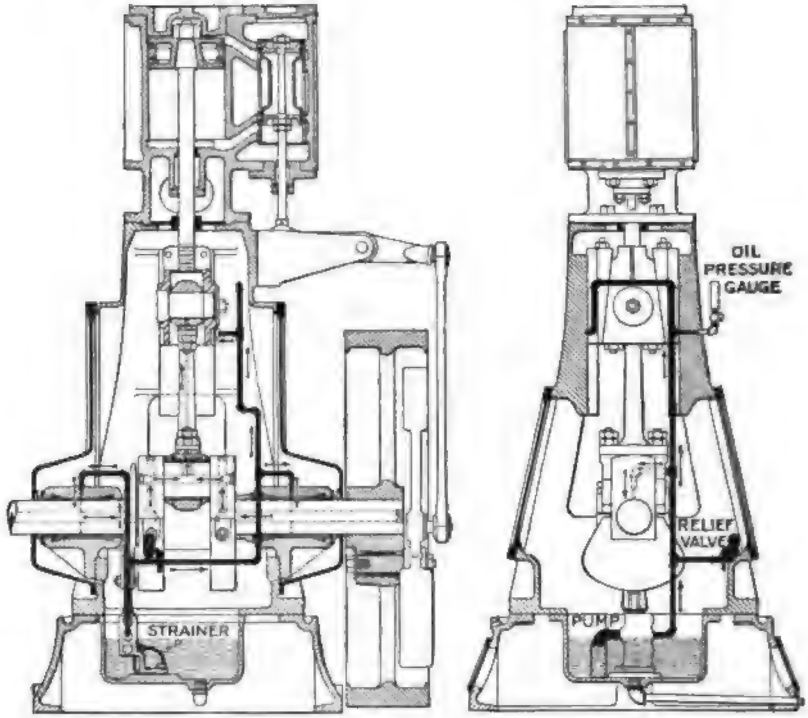


FIG. 2.—SECTION OF VERTICAL ENGINE BUILT BY THE B. F. STURTEVANT COMPANY, HYDE PARK, MASS., WITH CYLINDERS RANGING FROM 5 X 5 TO 12 X 10 INCHES. 6 TO 43 H. P.

FIG. 3.—AUTOMATIC ENGINE BUILT BY THE AMERICAN BLOWER CO., OF DETROIT, MICH., IN SIZES FROM 2½ H. P. UPWARDS

power for such service during the time when the private plant is not in operation, but, as a rule, the prices for rented power are so exorbitant as to be prohibitive.

Accordingly, we find small steam engines used for driving blowers or fans, for heating and ventilating, or for supplying draught for boiler furnaces. We find them again in the boiler room, driving mechanical stokers or running centrifugal pumps to force either cold or warm water. The steam engine has one strong claim for recognition in this service: it will usually go when called on. It may not be very economical, it may not run smoothly, it may pound and rattle and squeak, but it will go when once started, and the same cannot be said always of the gas engine or the electric motor. The small steam engine also has a faculty of taking care of itself under extremely adverse conditions; where the dust and dirt

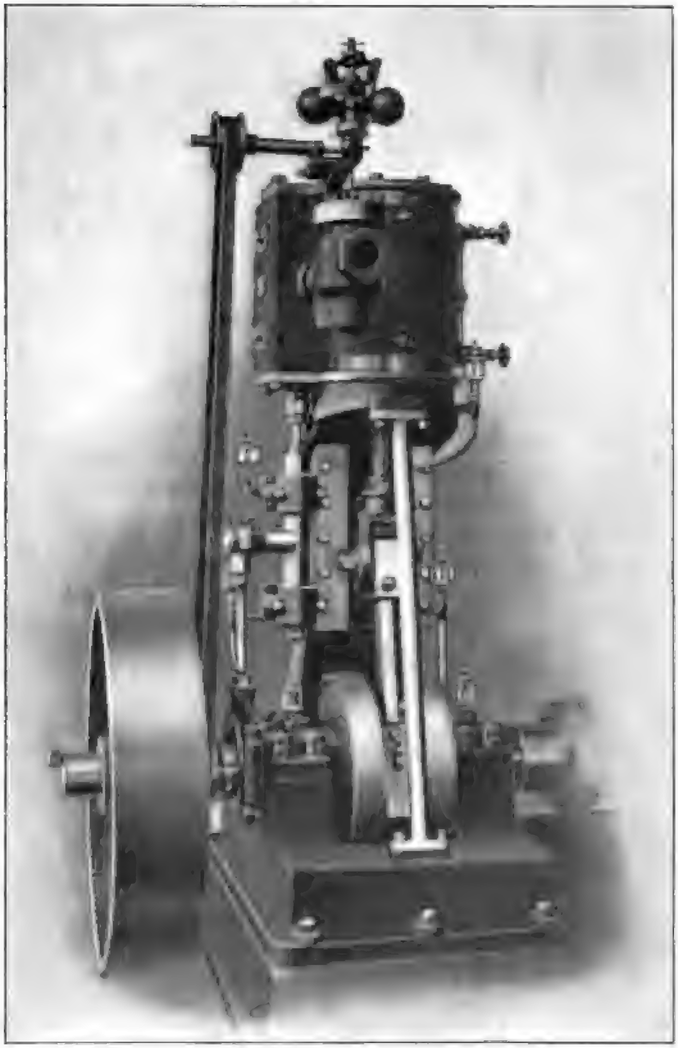


FIG. 4.—AN OPEN-FRONT ENGINE BUILT BY THE LAWRENCE MACHINE CO., LAWRENCE, MASS.

and grease would discourage nearly every other form of motor, the engine will plod along cheerfully until it is worn out.

An examination of the illustrations in this article will show that practically all of the smaller steam engines are of the vertical type. This has come about as a natural result of limited floor space and plenty of head room in locations where this class of motor is desirable. As long as the engine is of such size that the vertical cylinder is within easy reach of the floor, this type has a decided advantage in the matter of economy of floor space and ease of access. When it becomes necessary to use ladders and galleries in order to reach the cylinder end of the engine, the vertical position is no longer advantageous.

The vertical engine has less vibration than the horizontal one under the action of the reciprocating forces and has less wear between piston

and cylinder and between cross-head and guides. These engines, for the most part, have the familiar A-frame, circular at the top to correspond to the outline of the cylinder, and flaring gradually to accommodate the

FIG. 5.—THE ACME MARINE ENGINE, BUILT BY THE ROCHESTER MACHINE TOOL WORKS, ROCHESTER, NEW YORK, BUILT IN SIZES FROM 1 TO 3 H. P.

swing of the connecting rod, as illustrated in Fig. 1. The frame is usually bored for the cross-head guides, and is bolted at the bottom to a sub-base. The sides may be open, as shown in this illustration, but provision is usually made for covering the openings and completely encasing the engine, as shown in Figs. 2 and 3.

Fig. 3 illustrates a frame without the sub-base and one which has particularly good outlines. It is simple, it is stable, and it pleases the eye.

Engines of a somewhat larger size are frequently built with an open front, in the yacht engine style, as in Fig. 4. Here one-half of the frame is replaced by a single steel column, lightening the construction and making the moving parts more accessible. The cross-head is necessarily of the slipper type, with guides at the rear.

Fig. 7 illustrates a smaller engine with open frame of a slightly different design. The cylinder is of the simplest type possible and is bolted to the end of the frame.

Fig. 9 further illustrates this type of simplicity,—flat cylinder heads, cast-iron lagging, and plain stuffing-box. This cut also illustrates the common style of piston,—a plain, hollow cylinder with flat ends and two cast-iron rings, sprung into position. The piston rod is usually riveted at the end and becomes a part of the piston. The absence of side wear in the vertical cylinder insures a comparatively long life for cylinder, piston and rod.

The valve is commonly a balanced slide or a piston valve, held to the stem by check nuts which allow adjustment of load. Fig. 9 shows the ordinary D-valve with a self-adjusting balance ring. This type of valve will relieve the cylinder of entrained water.

Many builders prefer the piston valve as shown in Fig. 2, on account of its perfect balance and simplicity. The valve in that illustration is fitted with packing rings, and slides in a renewable bushing. Although notable

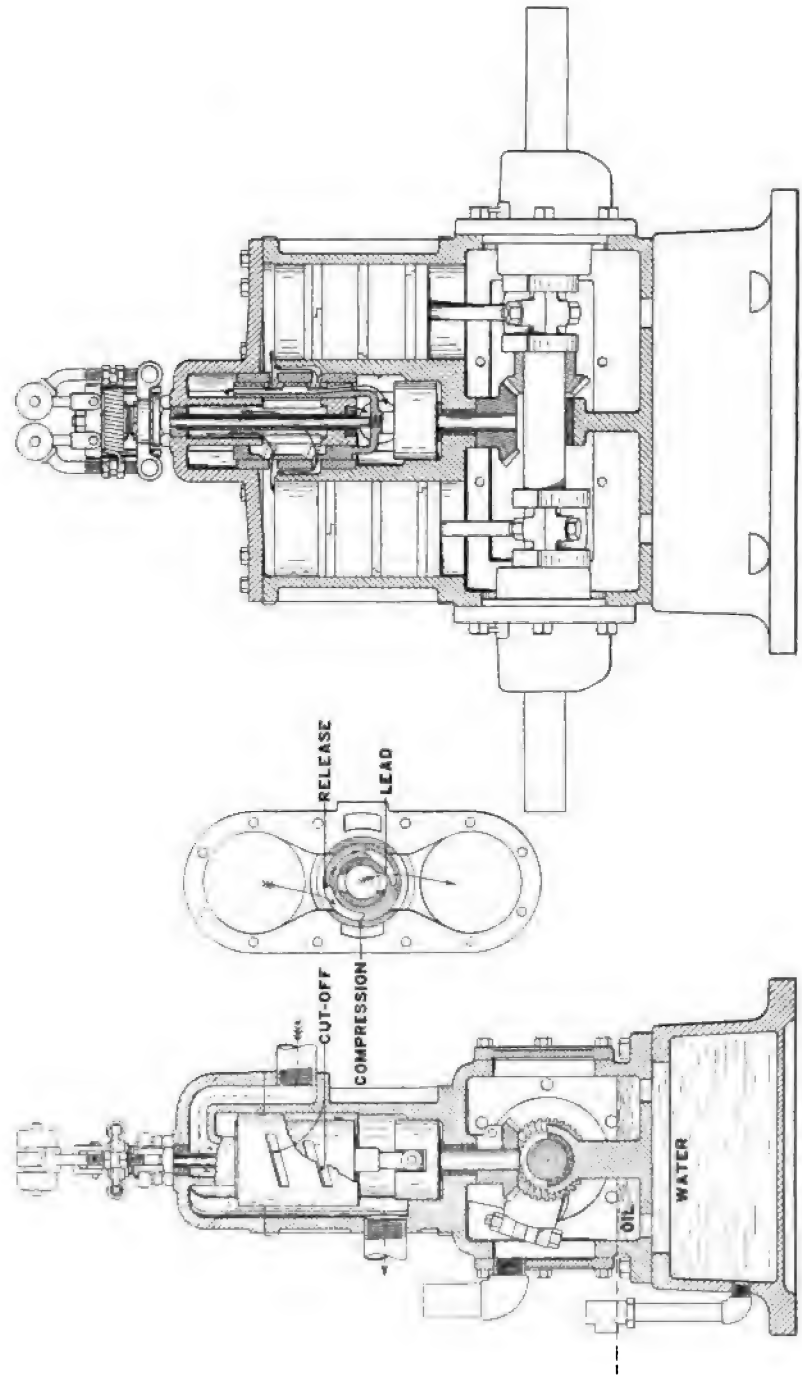


FIG. 6.—SECTIONAL VIEWS OF THE FRANCKE ENGINE, BUILT BY THE U. S. RAPID-FIRE GUN & POWER CO., DERBY, CONN., IN SIZES FROM 2½ TO 30 H. P.

for its ease of movement, the piston valve is not adjustable for wear and sometimes causes trouble when water enters the cylinder. The cylinder shown in Fig. 2 is provided with relief valves. The shape of the cross-head naturally depends upon that of the frame.

When the more common A-shape of frame is adopted, as in Figs. 1 and

FIG 7.—ANOTHER OPEN-FRAME DESIGN BUILT BY THE MORRIS MACHINE WORKS, BALDWINSVILLE, NEW YORK, IN SIZES FROM 1½ H.-P. UPWARDS

3, the guides are bored in line with the cylinder and the cross-head takes the shape shown in Figs. 10 and 11. The body of the cross-head is a steel casting and the shoes are of bronze, the latter being adjustable endwise by studs and check nuts. The importance of having a cross-head which is at the same time strong and light is now generally appreciated.

The open-front engine, Figs. 4 and 7, demands the slipper cross-head, with two rectangular slides behind the rod,—a form not so strong and stiff as the one just mentioned, but rather more accessible. The so-called marine type of connecting rod seems to be the favourite, as may be seen by reference to several of the illustrations, notably Fig. 10. This type of stub-end is particularly well adapted to center-crank engines, since it is compact and can be easily adjusted or removed. The rod should be of forged steel, but steel castings can be used for the crank boxes. Most of the rods shown have a solid end for the wrist-pin and the cross-head is disconnected by removing the pin.

The inaccessibility of the cross-head end of the rod in many of the designs illustrated makes the use of straps and keys entirely impracticable. Notice how the adjustment of the boxes is effected in Fig. 10 or Fig. 11 without access to the interior.

The crankpin and shaft are usually forged in one piece, as should always be the case with center-crank engines. The counterbalance is of cast iron and is attached to the crank in a variety of ways. Fig. 12 illustrates two shapes of counterweight, fastened to the crank by bolts and having the bolt cavity filled with lead.

Most manufacturers of small engines are prepared to furnish either an automatic cut-off or a throttling governor. Fig. 7 illustrates the application of the throttling governor, the valve being a slide, driven by a stationary eccentric. A somewhat similar arrangement is shown in Fig. 4. The Rites inertia governor seems in America to be the most popular of the automatic class and may be seen in several of the illustrations, as in Figs. 1 and 3. This governor is

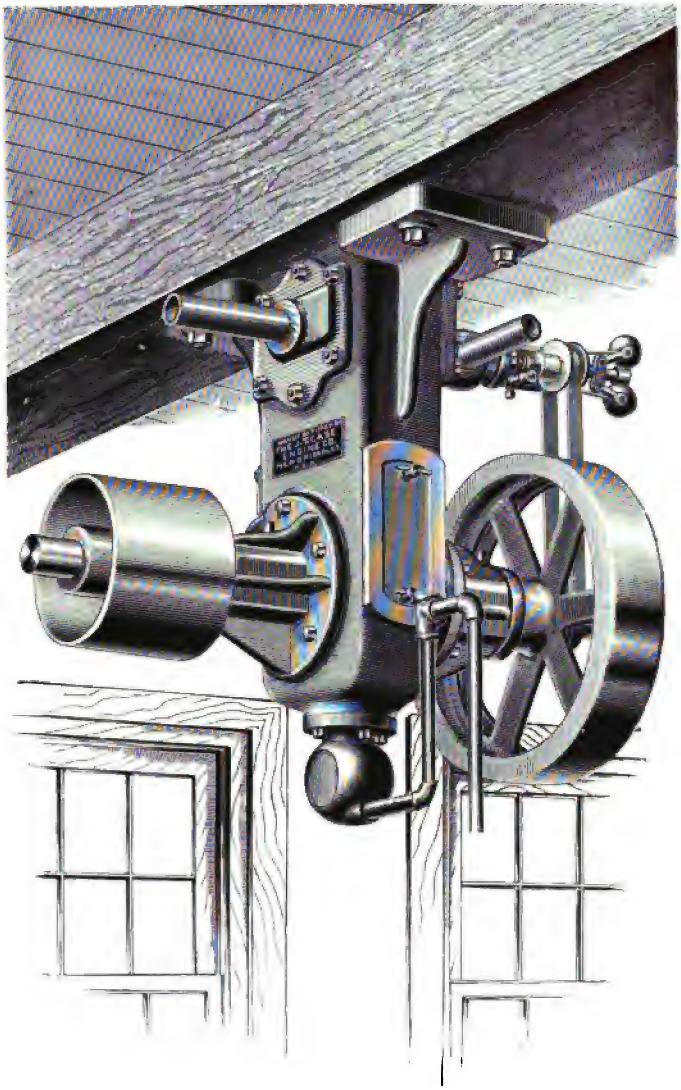


FIG. 58.—A CASE ENGINE, SUSPENDED FROM OVERHEAD, MADE BY THE NEW BRITAIN MACHINE CO., NEW BRITAIN, CONN. THE ENGINE RANGES FROM 2¾ H. P. UPWARDS.

simple and sensitive, the engine builders guaranteeing a regulation of from 1 to 2½ per cent. between no load and full load. For some purposes, however, the throttling governor is just as good, and it is considerably cheaper.

Perhaps the most notable improvement in small, high-speed engines is in the matter of lubrication. The progress has been gradual from the old-fashioned grease cup or wick oiler, to the stationary sight-feed oiler, and then to the systems of forced lubrication.

An engine which is used for fan and stoker service is always labouring under the disadvantages of constant dust and inconstant attention. A system which will protect it from the consequences of dust and neglect is certainly desirable. The enclosed

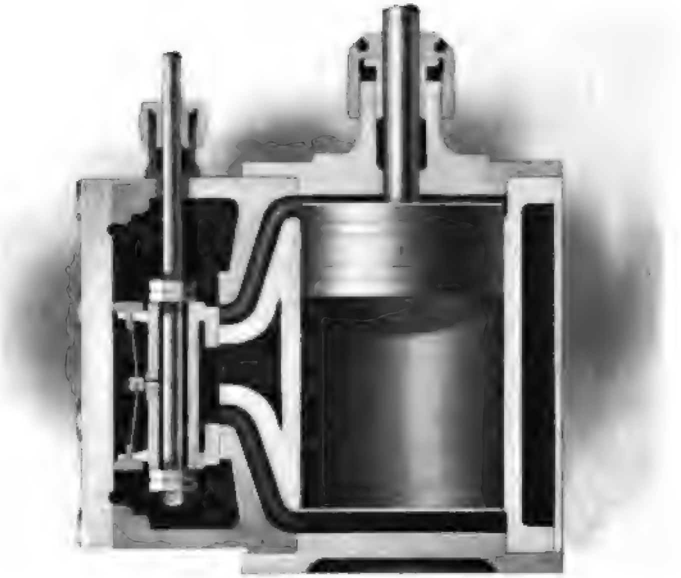


FIG. 9.—VERTICAL SECTION OF THE TROY ENGINE CYLINDER AND VALVE CHEST

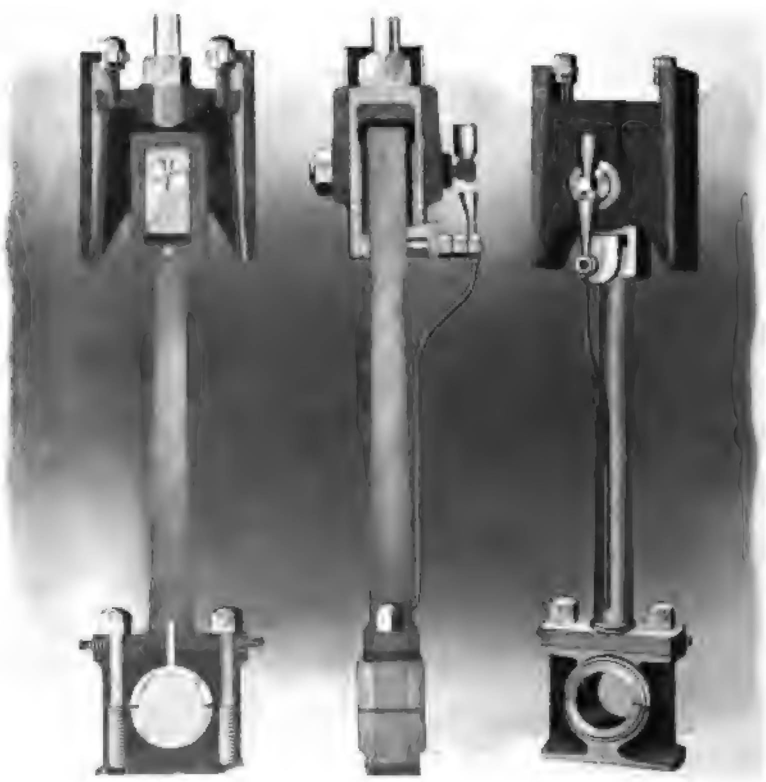


FIG. 10.—THE CONNECTING ROD OF THE TROY ENGINE

frame, such as that shown in Fig. 2, affords that protection. At the same time it raises the temperature of the enclosed portion and makes a thorough system of lubrication necessary. The illustration shows a force pump sending oil under pressure to all the bearings, whence the oil returns by gravity to the tank at the bottom. A tight partition separates the case from the cylinder head and prevents oil and water from getting together.

The engine illustrated in Fig. 3 has a somewhat similar method of oiling. The oil in this case is pumped from a reservoir in the bottom of the frame to a tank at the top, whence it is distributed by gravity to the various bearings. Fig. 14 shows the lower reservoir and the means employed for oiling the crank-pin and the main journals of this engine. The tube *D* in the figure oils the crank-pin; the cups marked *II* catch the drip from the cross-head, from which it is conveyed to the main journals. The ring *K* catches the oil from *D* and also from the end of the adjacent bearing and conveys it to the crank through holes at *O*. The eccentric at *N* is oiled by the drip from the outer end of the journal and all the oil finally runs into the reservoir where it is automatically strained and filtered before again going on its rounds.

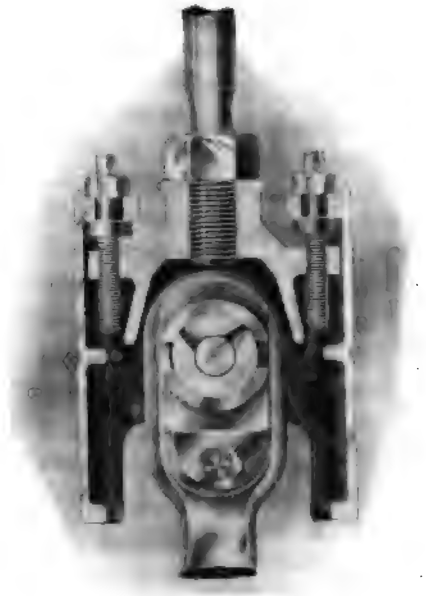


FIG. 11.—THE CROSS-HEAD OF ONE OF THE AMERICAN BLOWER COMPANY'S ENGINES

The builders state that one of these engines ran 14 hours a day from March 10 to July 15 of the same year with one filling of oil and without adjustment. The only attention required was the filling of the cylinder lubricator. Some of the methods adopted for gravity, sight-feed

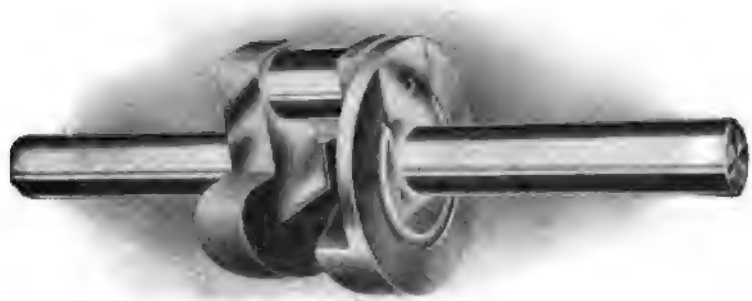


FIG. 12.—THE CRANKSHAFT OF ONE OF THE AMERICAN BLOWER COMPANY'S ENGINES

oiling are shown in Figs. 1, 4 and 10, and these hardly need description.

Several of the engines illustrated in this article differ in a marked degree from those just described. There are, for example, the single-acting, double-cylinder engines of the Westinghouse type, such as those shown in Figs. 5 and 6. The freedom of the single-acting engine from back-lash, and the balance of reciprocating forces with two cranks at 180 degrees, are strong arguments for the adoption of this type. The absence of a piston rod and cross-head gives compactness, and the complete encasing of the engine is a good feature.

Fig. 5 shows such an engine equipped with a link motion and adapted for use in a small boat where its low center of gravity is an advantage. The valve used is the familiar oscillating cylinder introduced by the Westinghouse Company. These engines are also built with skeleton frames of bronze for automobile service, the entire weight of a 10-H. P. engine being about 145 pounds.

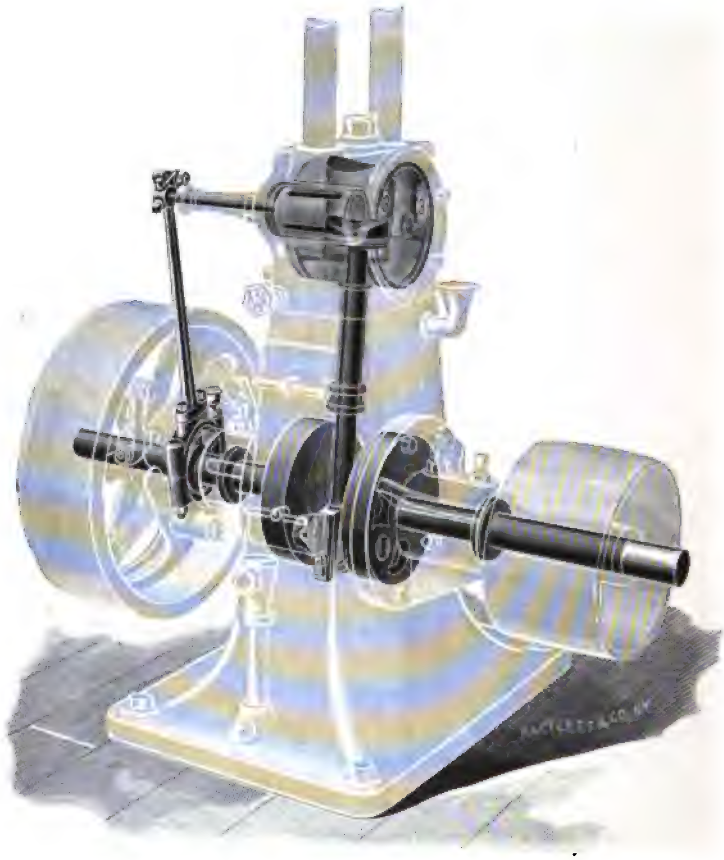


FIG. 13.—THE WORKING PARTS OF A CASE PEDESTAL ENGINE.—SEE ALSO FIG. 8

The oscillating engine illustrated in Figs. 8 and 13 is unique and possesses some decided merits. Its peculiarities may be best understood by reference to the latter figure, which shows the working parts inside the casing. The frame is a single pedestal or cabinet, of good outlines and well balanced. There is nothing

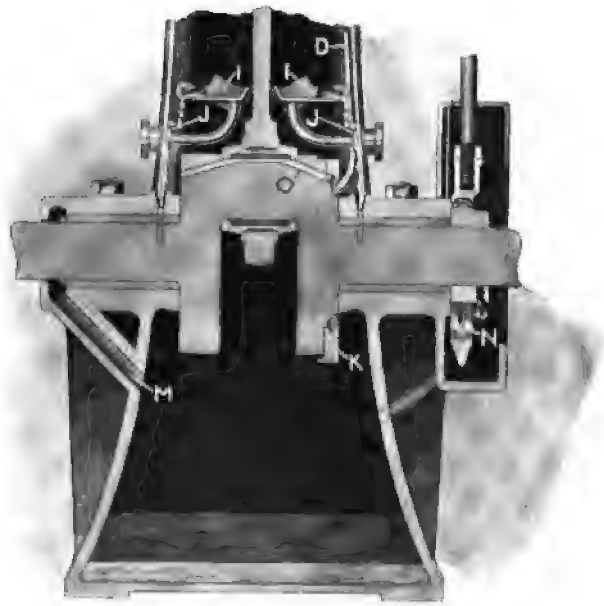


FIG. 14.—SECTION OF BASE OF THE AMERICAN BLOWER COMPANY'S ENGINE SHOWN IN FIG. 3, ILLUSTRATING METHOD OF OILING THE CRANK-PIN, JOURNAL BOXES AND ECCENTRIC

about the crank and main shaft which calls for special mention. The peculiar features of the design are the piston and cylinder. The piston is fastened to the end of the rod and is single acting, while the cylinder oscillates in the upper part of the frame.

The cross-head and connecting rod are thus eliminated and the weight of the reciprocating parts is reduced to a minimum, being only 12½ pounds for an 8-H. P. engine. The cylinder is rocked in its casing by a sleeve outside the rod, and has large bearing areas so that the wear is slight. It is balanced on the down stroke by the reaction of the steam on the upper head, and on the up stroke by a thin film of steam admitted to a chamber in the bottom. The motion of the cylinder controls the admission and release of the steam, while the cut-off is regulated by an oscillating valve controlled by a shaft governor.

There are few parts to be lubricated and these are well taken care of. The cylinder and valve are lubricated by a sight-feed oiler, while the crank-pin dips into an oil reservoir below at each revolution. The same reservoir furnishes oil for the main journals.

Fig. 8 shows the same engine hung from above for direct connection to line shafting. This cut illustrates the application of a throttling governor in place of the automatic cut-off. The total shipping weight of a 4-H. P. engine of this type is only 325 pounds.

The use of the small steam engine for purposes of propulsion on water and on land, is another phase of this general subject which would afford material for a separate article. The engine illustrated in Fig. 6 belongs to the same class as that just described, but has an entirely different valve motion and governor. The valve is a rotary sleeve between the two cylinders, turned by bevel gears on the main shaft. The steam enters the inside of the valve and passes into either cylinder alternately through ports cut in the shell.

The steam is exhausted through similar ports on the opposite side of the valve. The governor shown at the top raises or lowers the valve as the speed changes, and on account of the peculiar shape of the ports, this movement varies the cut-off and compression without changing lead or release. This method of governing has the advantage of regulating the inflow of steam and at the same time maintaining the most economical distribution of the steam.

This is decidedly a high-speed engine, a 4 by 3½-inch, running at speeds of from 300 to 550 revolutions per minute and developing from 3 to 6 horse-power.

Fig. 15 shows a form of engine adapted for either compressed air or steam, driving a hoist.

Fig. 16 illustrates the Dake square piston engine, a type of direct or rotary engine, which is certainly interesting for its simplicity if nothing more.

The latest comer in the field of small American steam engines is the Roteng motor, shown in Fig. 17. It consists essentially of multiple cylinders radially disposed around a hollow shaft. It is not to be considered a rotary engine, but is a combination of single-acting reciprocating engines all connected to the same shaft, in which the cylinders are not stationary, but revolve with the shaft. The pistons or plungers are suspended by yokes revolving on circular bearings, eccentric to the shaft bearings. When steam is admitted under a piston the pressure produces a force acting on the center of the eccentric, which corresponds to the crankpin of an ordinary engine. The difference is that the pin is stationary and the reaction causes the displacement of the cylinder upon its piston, and the tangen-

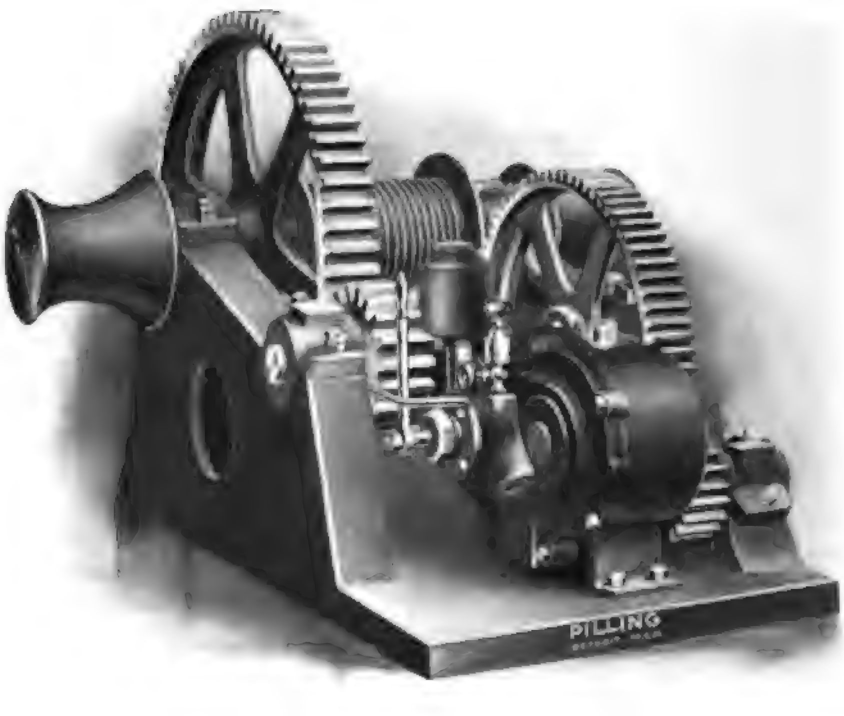


FIG. 15.—THE PILLING ENGINE DRIVING A HOIST. BUILT BY THE PILLING AIR ENGINE CO., DETROIT, MICH. THIS ENGINE MAY BE OPERATED WITH EITHER STEAM OR COMPRESSED AIR. SIZES RANGE FROM 2 TO 8 H. P.

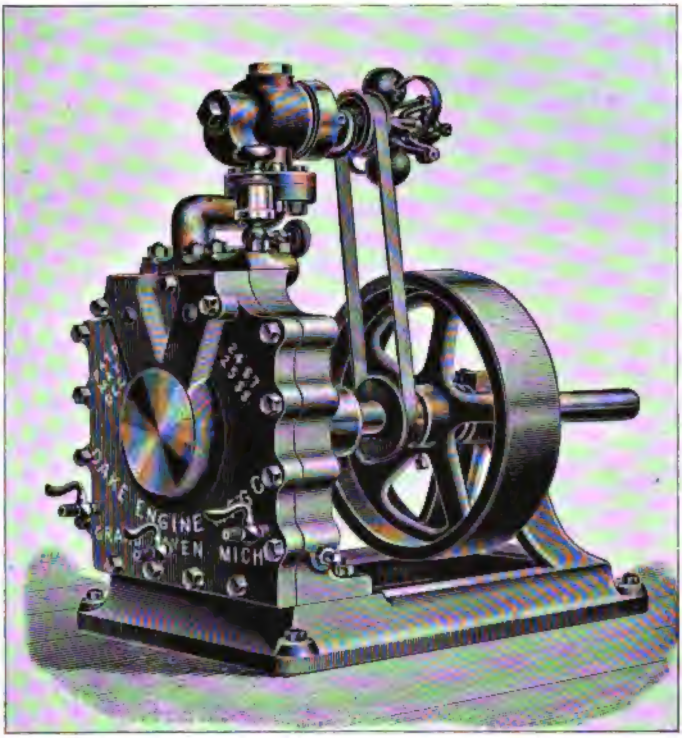


FIG. 16.—A SQUARE PISTON ENGINE BUILT BY THE DAKE ENGINE CO., GRAND HAVEN, MICH., U. S. A.

tial component of the force produces the rotation of the cylinders about the shaft. There is no dead center to the machine as a whole, because at least two pistons are always off center, and one of these is on its working stroke.

One field for the small steam engine, which it is likely to hold against all competitors, for the present at least, is that of temporary power for building operations. The whir and puff of the hoisting engine or the concrete mixer are very familiar sounds to those who dwell in cities, the language of a humble, but necessary, servant of the building contractor. The traction engine and

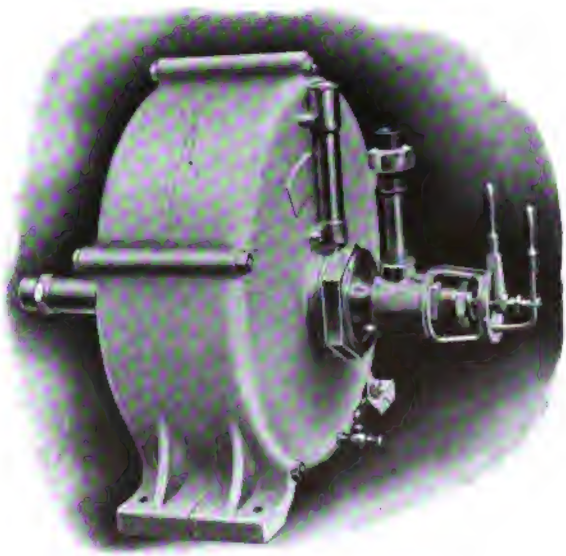


FIG. 17.—THE ROTENG MOTOR, MADE BY THE ROTENG ENGINEERING CORPORATION, NEW YORK

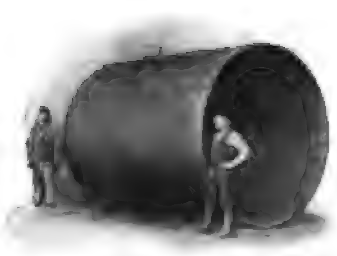
the hoisting engine cannot be discussed intelligently except in connection with the portable boiler, and this would open up another field.

The electric motor has usurped many of the functions and prerogatives of the small engine, but from the very nature of things some work still remains which this bustling little servant can do better than others. As long as man continues to put more and more labour onto machines and to do less and less by hand, the small steam engine need not fear to find its occupation gone.

THE LABOUR PROBLEM IN GREAT BRITAIN

A PROPOSED SOLUTION

By T. Good



IN our industrial life today we have a combination of circumstances of unusual interest, —conditions making for progress or for retrogression, according to the individual point of view adopted. One student of economics tells us that the signs of the times are distinctly satisfactory, eminently gratifying; whilst another gravely assures us that we are going headlong to ruin in industrial affairs, that commercial decay is already upon us, and national destruction within measurable distance! And each of these extremists can quote abundant evidence apparently to prove his particular contention.

On the one hand, we see a movement towards industrial peace, progress, and prosperity; we see labour disputes settled by conciliatory and statesmen-like methods; we see the barbarous strike giving way to diplomatic arbitration; we see wages in some cases regulated by selling prices; we see a tendency towards profit-sharing and copartnership between employer and employed; we see representatives of both capital and labour working jointly for reforms; we see the great king of commerce and the labour agitator hobnobbing together in the House of Commons. We see a growing spirit of toleration, a broadening of public opinion, and a spread of humanitarian ideas distinctly indicative of industrial welfare and national well-being.

But, on the other hand, we see a widening of the gulf between capital and labour; we see the individual employer, with his personal interest in his workers, being swallowed by the greater capitalistic corporation, ceasing to be an employer in the true sense of the word, and becoming but a shareholder; and we see the corporation, or company, becoming, in turn, but a mere unit of the still larger syndicate, or "trust,"—an evolution tending to the destruction of mutual sympathy and respect between the two primary forces in industrial production.

And whilst we see capital thus becoming more organized, more mechanical in its operations, and, we may justly say, more ruthless because more impersonal, we see the workers also losing their individuality, combining more effectively in their labour unions, accumulating larger sums of money for the purposes of industrial warfare; and not only this, but we see organized labour, en-

couraged by weak and vacillating politicians, largely controlling, in fact dominating, our parochial, municipal, and imperial politics, forcing the pace of industrial legislation which restricts and harasses the free operation of business at almost every turn.

We find organized capital thinking more and more of private dividends, and less and less of public well-being, whilst we find organized labour not only destroying the freedom of contract between man and man in industrial bargaining, but backing up extravagant schemes of State and municipal enterprise which compete with private effort directly, as well as damage it indirectly through increasing the burden of rates and taxes. In short, we see employer and employed becoming more estranged, capital and labour becoming more antagonistic, a process resulting in lack of energy, of conscientious purpose, and of faithful service in the worker, and in lack of feeling, of tolerance, and of benevolence in the employer. And this want of co-operation between capital and labour is, in turn, detrimental to national welfare.

Whether we incline to the pessimistic opinion that everything is going wrong, or to the more optimistic view that things are going solidly, if slowly, in a right direction, there remains no question that there is vast room for improvement. Such affairs as are going wrong need to be righted, and such as are going right need their rate of progress accelerated. In any case, there are grave questions demanding attention, and difficult problems awaiting solution.

In the first place, we should always remember, when approaching any aspect of the labour question, that we are about to deal with a human, and not with a mechanical, problem. The labour question is essentially a question of human nature,—of the fads, failings, and fallibilities of humanity.

Secondly, whilst discipline of the right kind is more conducive to efficiency than is grandmotherly pampering, yet we should recognize that a cast-iron rigidity of workshop management, heedless of individual susceptibility, emotion and passion, heedless of individual ambition, heedless of individual ability and inclination, tends to a dead level of mediocrity in craftsmanship, destroys the worker's interest in his employer's welfare, and retards progress.

Thirdly, we should realize that that country in which the workers are the best educated, the best nourished, and the best housed, is the one to attain the highest degree of national prosperity,—that a nation alike in industrial and imperial affairs is very largely what its manual workers are able and willing to make it.

In the growth of commercial trusts and the syndication of capital, with the consequent elimination of the small employer, on the one hand, and in the development of trade unionism on the other, I see no terrors. I believe that this process of organization on both sides will do, and is now doing, more good than harm. At the same time, I fully recognize the attendant evils and dangers of our industrial system as at present conducted. For good or for ill organized capital and organized labour have arrived, and each side will strive to strengthen its organization. This we may regard as inevitable, and make the best of it. The problem to consider, therefore, is how to make the best of the circumstances in which we find ourselves,—how best, with the means at hand, to cultivate industrial efficiency.

Many, if not most, of the ills that afflict industrialism would speedily be extirpated if employers and workmen understood one another better. For the prevalent misunderstanding I am certain that employers, as a class, are primarily responsible. The employer who never condescends to speak to his workmen, who goes through his works like an Oriental emperor, imagining himself to be an

awe-inspiring demigod, leaving the entire control of his workers to subordinate officials, and sending his sons to high schools to learn Latin and Greek, and to become so-called aristocrats instead of business men and works managers,—such an employer does nothing to gain the respect of, or to cultivate efficiency in, his workers; but he does much to promote distrust and contempt, and sets a premium upon indolence. It is this type of employer that has brought trade unionism and its restrictions to the front; it is this type of employer alone that has created the necessity for industrial legislation and its vexatious burdens.

From time to time it is alleged that American industrial methods are generally superior to British methods; at any rate, it is usually acknowledged that the Americans cultivate individual effort and initiative much better than we do. This can be readily understood if we consider for a moment that in America business is practically the be-all and end-all of existence, that there is no higher rank than that of the successful business man; whilst with us Britishers business is generally regarded as a mere stepping-stone to a "higher society."

This fact stands out clearly even in the matter of education, for our high schools and universities are virtually the preserves of a leisure class who scorn commercialism, apparently oblivious of the fact that commerce maintains the nation. Most of our great employers are by no means captains of industry in the best sense of the term; their chief thoughts are of knighthoods and peerages, of getting themselves and their children into the charmed circle of "smart society," whilst they delegate their authority and duties as employers to officials.

The gulf between the employer, or managing director, and the man who uses the tools is far too wide. Why should the employer, or manager, consider it *infra dig* to be personally acquainted with the man who tends the machine? One of the most serious charges against trade unionism is that of preventing employers paying workmen according to merit. But where is the employer to-day, or even the manager of a large establishment, who is aware of the individual merits of his men?

The average employer has neither the will nor the ability to reward and encourage individual merit in his workmen, for the simple reason that he does not know, nor does he attempt to ascertain, their individual qualifications. The average employer will pay minute attention to the buying and selling of goods, and he will closely examine a new machine, but to work out a labour or wage system suitable to his particular establishment or trade, to adopt methods by which men may be encouraged to give the best possible results for a given area of shop space, or in a given time, or with a given quantity of material; to improve the efficiency and health, and to increase the willingness of his workers,—to the real problems of labour, and of rapid and economical production,—these are the very last subjects to which our average employer has devoted his mind.

The problem of wages is undoubtedly the greatest question with which we have to deal in reference to labour. The evil lies in the fact that we pay positions instead of persons. We place our workers in groups or divisions, and pay a certain wage-rate to all those in this group, and another rate to all those in that group, regardless of the individual services rendered. Such a system is opposed alike to efficiency and to real economy. It is a levelling-down policy which seriously retards individual effort.

To lay the whole, or even the chief blame for the existence of this system upon trades unionism is not strictly honest. Employers are equally to blame. There is no greater progress, there is no better cultivation of efficiency, there is no

more rewarding of individual merit in those industries which are free from trades union interference than in those largely dominated by organized labour. The fact is, that the average employer, or manager, takes little interest in, and has no knowledge of, the individual qualifications of his workmen, and, therefore, merit is neither cultivated nor rewarded,—a condition just as prevalent in "free" labour as in "union" workshops.

Even when the shop foreman is aware of special merit in some of his men he is not allowed by the management, as a rule, to increase the wages of such men. I write from practical experience of British workshop methods, and I say, without fear of contradiction, that it is well-nigh impossible to find, throughout the length and breadth of the country, a large shop in which the best worker is paid a single shilling a week more than the worst one! Foremen are not usually permitted to arrange wages, or conditions, so as to either attract to their shops the best workmen in the district, or to reward the best men under their control.

Wage-paying methods should occupy our strictest attention, for they are as vital to industrial efficiency as industrial efficiency is to national welfare. But two cardinal facts should always be kept steadily in view,—first, that cheap workmen do not necessarily mean cheap production; and secondly, that the main factor in national trade prosperity is a high standard of living (through high wages) among the working classes who form the bulk of the community.

In fixing a wage-paying method, or in establishing any system of works management or policy of controlling production, the human element with its human prejudices, its personal fads and susceptibilities, and its individual capabilities should be taken into the fullest account. The man who plies the tools and tends the machine should always be considered, and on every possible occasion should be consulted and encouraged to talk over shop matters in his own way. Not only would many valuable suggestions be obtained, but that sullen feeling of distrust in the employer, and that contemptuous disregard of the works welfare, that so detrimentally affect industry, would be banished. But in workshop life there is a palpable and painful neglect of this important human element. Systems and policies that vitally affect the pay, the work, the health, and the comfort of the workmen,—systems and policies, the success of which often depends entirely upon the workmen,—are put into operation with an absolute disregard of his ability or willingness to achieve satisfactory results under them.

As far as is possible the employer, or manager, should be personally acquainted with the men at the bench. But where, owing to the largeness of the works, personal contact is difficult, I would suggest the formation of works consultative committees. Once or twice a year the workmen should be invited to elect, by ballot, representatives or committeemen, who should attend a monthly meeting convened by the management. These meetings should be attended by the principals of the respective firms, by their managers and foremen, as well as by the practical representatives of the workmen, and full and frank discussion should take place upon every topic affecting the works, the workers, and the industry in general. Even if abstract political questions were introduced, some good, and no harm, would be done.

In very large establishments records, or minutes of the proceedings of these consultative committees should be published in a monthly journal, and distributed among the workpeople. Through these committees the employers would be made aware of many evils and abuses of which they are now ignorant,—evils and abuses often constituting real grievances which, although they never

come to light, cause discontent in, and have a demoralizing effect upon, the workers. Remedies could be applied, a better feeling between employer and workman engendered, and the rate of industrial progress in general accelerated. The necessity for cultivating mutual respect and understanding between employer and worker, and for promoting honest dealing in our workshop affairs, cannot be too strongly urged.

In recent years the British workman's indolence has often been severely criticised. But why this indolence, if indolence there be? I have studied this labour problem on the spot. I have been behind the scenes, and it is because personal experience of our industrial ills and their root causes has driven me to conclusions not in accordance with those generally accepted that I make bold to discuss so freely, and at such length, this difficult problem of industrial efficiency.

Knowing what I do of our workshop methods, the wonder to me is that the workers, man for man, perform as much honest work as they do, for it is seldom indeed that individual effort is encouraged in this country. I say that in a very large proportion of British workshops honest craftsmanship and faithful service are never rewarded! More often, the man who gets on the best, who is given the cleanest and most comfortable jobs in the shop, who is given constant employment during periods of depression when others are suspended, and who is signaled out for promotion, is the one who attends the same place of worship or the same public-house as his foreman, or the one who is always tittle-tattling and carrying tales to his manager. Broadly speaking, our entire system of workshop management militates against efficiency and progress.

The conscientious foreman must not suggest an increase of pay for the best workmen, whilst the dishonest foreman is unchecked, because the employer is unaware of the exactions and tyrannies imposed upon the workmen by him. But the establishment of such workshop committees as I have suggested would be the means of cultivating that which is best, and extirpating that which is worst, in our workshop management, for all matters of interest, good and bad, would come to the knowledge of those concerned. Good men would be duly rewarded, inefficient ones singled out for development or discharge, and, generally, men would be placed upon those jobs for which they have the greatest aptitude or inclination. The entire aspect of our workshop life would be changed for the better.

Besides these works consultative committees I would suggest the formation of industrial district councils, jointly composed of representatives of local chambers of commerce, of local employers' associations, and of the local branches of trade unions. Many questions of vital interest to industry,—questions of mutual interest to employer and workmen,—such as local rating, local "by-laws," technical education, housing schemes, etc., etc., could be dealt with in an authoritative manner, and valuable advice could be given to, and legitimate pressure brought to bear upon, the proper authorities. It is high time for organized capital and organized labour to pull together wherever possible.

In addition to workshop committees to deal with workshop matters, and district councils jointly composed of employers and workmen to deal with local questions, I venture to propose the establishment of a national council of industry, representative of the employers' associations and the workmen's unions, to meet regularly and discuss general topics affecting trade and labour, to gather information upon all subjects connected with the industrial well-being of the nation, and to issue reports and recommendations thereon. By these means much prejudice could be removed,

many dangerous fallacies and misconceptions cleared up, costly and bitter conflicts between capital and labour could be avoided, and industrial peace and progress effectively nurtured. Such an authoritative body as this council of industry would be, if brought into being, in addition to promoting good-will and efficiency in purely workshop affairs, could act as a powerful instrument in moulding public opinion in favour of such reforms as are really needed in the interests of industrial freedom and welfare, and in checking that paltry and pettifogging legislative interference with trade and labour which, although it may be well-intentioned, is frequently detrimental in its effects.

But over and above these material considerations there is the more moral,—the more fundamental because the more human,—necessity for personal contact between representatives of capital and labour. It is not sufficient that the employers and the leaders of our most skilled and best organized workmen should come together only during the more or less heated controversy of a labour dispute. We want the best brains on both sides to be working in harmony for the common good.

THE WORLD'S COPPER OUTPUT

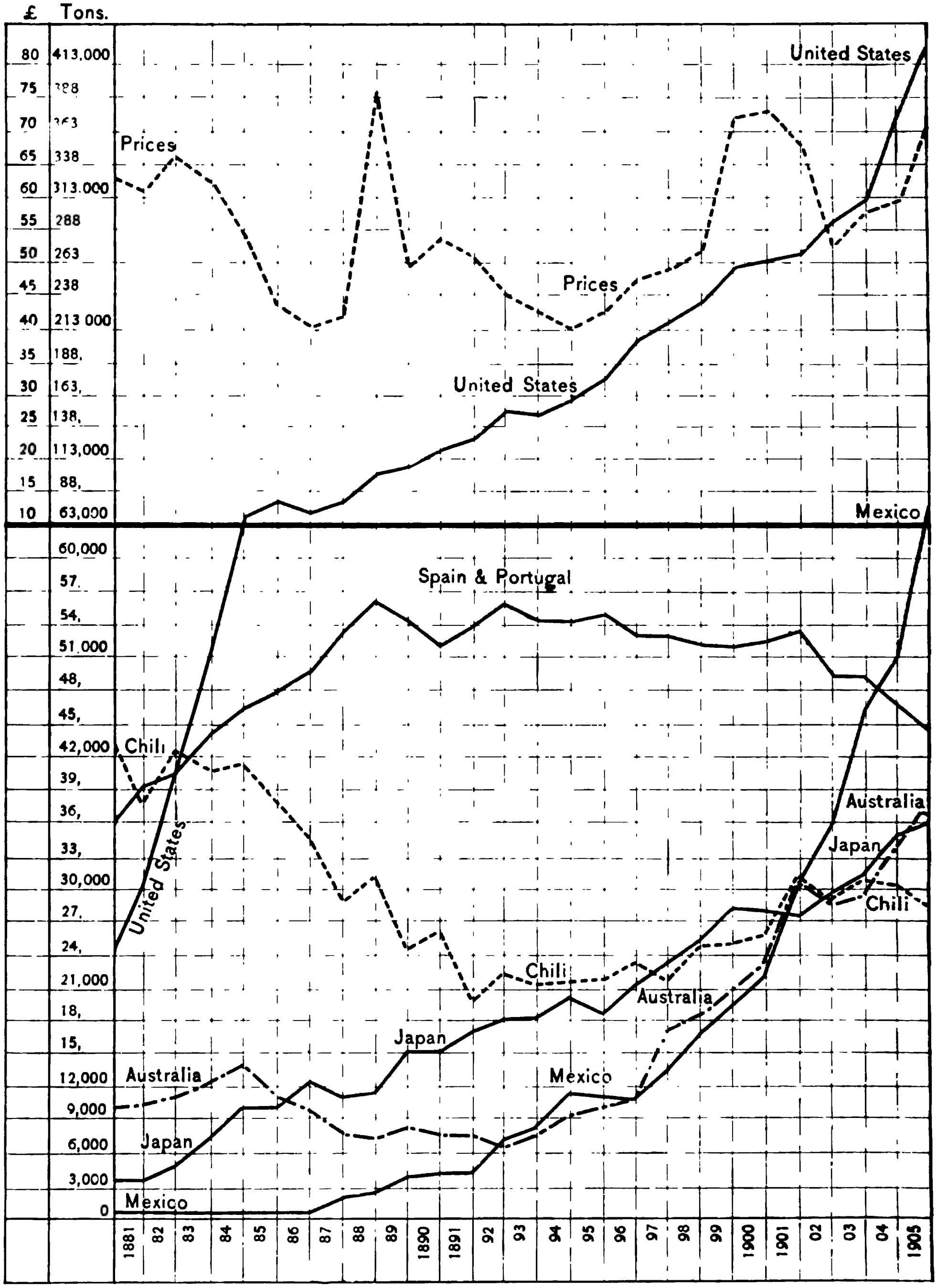
FOR THE PAST TWENTY-FIVE YEARS

By John B. C. Kershaw, F. I. C., F. S. S.

THE rise of £11 per ton in the price of copper in 1905, coincided with an increased production of 64-000 tons, naturally caused some uneasiness in the minds of large users of the metal in the electrical engineering and shipbuilding industries. The present scarcity of the metal serves to direct attention to the chief sources of supply, and to the question how far these can be developed to meet the increased demand for copper in the arts and industries of the world.

In the following pages the author has brought together information relating to the output of raw material by the twelve leading copper producing countries during the last twenty-five years, and has traced the rise or fall of the various countries as indicated by their contribution to the aggregate copper production of the world. Particulars are given also relating to the development and growth of the electrolytic refining industry, and figures bearing upon the consumption and price movements during the last twenty-five years.

The more important figures contained in this article have been reduced to diagrammatic form on the next page. The diagram there given covers a period of twenty-five years, and each lateral division represents one year. Each vertical division equals 3000 tons in the lower portion of the diagram, and 25,000 tons in the upper portion. This difference in scale is necessary in order to bring the curve for the United States production within the limits of the diagram. The six countries in 1880 were



THE WORLD'S COPPER OUTPUT FROM 1881 TO 1906

producing copper in the following order as regards output:—Chili, Spain and Portugal, United States, Australia, Japan, Mexico. In 1905 the relative positions were as follows:—United States, Mexico, Spain and Portugal, Australia, Japan, Chili. Four of these countries have greatly increased their output, namely, the United States, Mexico, Australia, and Japan. In the case of Spain and Portugal, and Chili, the production is declining.

The dotted curve in the upper portion of the diagram represents the variations in price during the twenty-five years from 1880 to 1905. Each vertical division equals £5. The curve shows three periods of high prices, namely, in 1888, in 1899 to 1901, and in 1905 to 1906.

The first of these was due to the Paris corner in copper; the second, to the formation of the Amalgamated Copper Company; and the third, to an unprecedented demand for the metal for engineering and coinage purposes. The low prices of 1886 and of 1894 would appear to be bed-rock prices for copper. The average profits of the producing companies in recent years must, therefore, have amounted to over £15 per ton, and the aggregate profits of the producing industry in the twenty-five years covered by this diagram, to the enormous total of £135,000,000 ($675,000,000), on a total production of 9,000,000 tons of copper.

STATISTICS OF PRODUCTION

The following figures are drawn from the annual statistical circulars published by Messrs. H. R. Merton & Co., of London, to whom the author's thanks are due for allowing this use to be made of the returns collected by them.

Since the whole of the figures contained in these annual tabular statements would occupy too much space, and would also prove somewhat indigestible for the ordinary reader, the progress made by the twelve leading producing countries has been separately dealt with, and the figures for the six most important of these have been reduced to graphic form and are shown in the diagram.

The United States.—In 1880 the copper mines of the States produced 25,000 tons of copper, the Calumet & Hecla mine being chief contributor to this total with 14,150 tons, while other Lake companies produced 8050 tons, and the Western States added only 2810 tons. The 1905 output of copper by the American mines amounted to the enormous total of 413,070 tons, to which the old Calumet & Hecla and other Lake companies contributed 101,565 tons, while the Montana, Arizona and Anaconda companies contributed the balance of 311,505 tons.

The important place occupied by America in the copper output of the world is thus seen to be due to the wonderful development of the mining industry in the Western States which now provide 44 per cent. of the total world supply of copper. The mines in Montana and Arizona are now adding most rapidly to the production, and it would seem impossible that the present rate of increase can be kept up. Since the year 1900 the output of the Montana mines has increased from 114,144 tons to 150,895 tons, and of the Arizona mines from 49,447 tons to 102,680 tons.

The general progress of America as a copper-producing country in relation to other countries and to the total world production, is indicated in the diagram.

Chili.—In the year 1880 Chili occupied the first place among the countries of the world as regards copper production. In that year the mines of Chili produced 42,916 tons of the metal, equal to 28 per cent. of the total output of copper. In 1905 Chili contributed only 29,165 tons to the world's total production, and had sunk to the sixth place, with a percentage of slightly over 4 per cent. The changes of the intervening years are shown in the diagram.

Spain and Portugal.—The mines

of the peninsula produced 36,313 tons in the year 1880, or 23 per cent. of the world's output, and Spain and Portugal ranked, therefore, as second to Chili among the copper-producing countries of the world. In 1905 the peninsula contributed 44,810 tons to the total supply of copper,—equal to only 6.3 per cent. The output of the leading mines in these two countries is on the decline, the maximum production (56,170 tons) having been attained in 1892. As shown in the diagram, Spain and Portugal now rank third in the list of producing countries.

GERMANY.—In 1880 Germany produced 10,800 tons of copper, chiefly from the Mansfeld mines, and the percentage contribution to the world's supply was 7 per cent. In 1905 the German mines produced 22,160 tons, equal to 3.1 per cent. of the total output, so that Germany has sunk in relative importance, though her output of copper has increased during the twenty-five years. The Mansfeld mines contributed 19,565 tons to the total for 1905.

AUSTRALASIA.—In 1880 Australia produced 9700 tons of copper, and the output of the country increased gradually up to 14,100 tons in 1884, when a decline set in which extended up to the year 1893. Since that year the production of the mines in Australia, Tasmania, and New Zealand has increased rapidly, and in 1905 these countries contributed 36,560 tons to the world's supply of copper,—equal to 5.1 per cent. of the total output of the metal. Australasia now ranks as fourth among the copper-producing countries of the world.

CAPE OF GOOD HOPE.—In 1880 the Cape contributed 5038 tons of copper to the world's supply. In 1905 the output of the Cape and Namaqua mines was 7325 tons, only a slight increase, and its position had sunk from sixth to eleventh in the list of producing countries.

JAPAN.—The rise of Japan as the most important country of the East has been accompanied by a great development of its metallurgical industries, and the output of its copper mines has undergone a striking increase in the twenty-five years covered by this review. In 1880 Japan produced only 3900 tons of copper and ranked as seventh in position. In 1905 its copper mines produced 35,910 tons of the metal, and the country now occupies fifth place. The increase in output is still continuing, as shown by the curve for Japan in the diagram.

RUSSIA.—In the year 1880 Russia contributed 3300 tons to the world's total output of copper; in 1905 the contribution had increased only to 8700 tons, and the resources of Russia as a copper-mining country are shown by this figure to be somewhat limited. The maximum output of the Russian mines was 10,700 tons in 1904.

NORWAY.—This country in 1880 produced 2426 tons of copper, as compared with 6295 tons in 1905. The output of the Norwegian mines is increasing to a very small extent.

PERU.—In 1880 Peru contributed 600 tons of copper to the world's supply, a total increased to 8625 tons in 1905. Curiously, the relative position of Peru remains unaltered, and it still occupies tenth place in the list of producing countries.

MEXICO.—Judged by percentage increase, Mexico has made even greater progress than the United States as a copper-producing country. In 1880 the mines of Mexico produced only 400 tons of copper. In 1887 the famous Boleo mine was opened up, and since that year the output has rapidly increased. In 1905 the comparatively large total of 65,185 tons was produced. This rapid increase in production is due chiefly to the re-opening of old mines dating from an early period of Mexican history, and the working of these by modern methods. The output of these mines is now 55,000 tons, whereas in 1900 it was only

11,050 tons. The Boleo mine in 1905 produced 10,185 tons of copper, and the production of this mine is practically stationary. Mexico now occupies second place among the copper-producing countries of the world.

CANADA.—The Dominion of Canada in 1880 added only 50 tons to the copper output of the world. In 1905 the mines of Canada produced 20,535 tons of the metal, and the Dominion had, consequently, risen to the eighth place in the list of producing countries, with a percentage contribution of 2.9.

The figures given in this brief review are summarized in the following table:—

COUNTRY	Production		Percentage of Total Output	
	1880	1905	1880	1905
United States	25,010	413 070	16.2	44.0
Chili	42,916	29,165	28.0	4.0
Portugal and Spain	36,313	44,810	23.0	6.3
Germany	10,800	22,160	7.0	3.1
Australasia	9,700	36,560	6.3	5.1
Cape of Good Hope	5,038	7,325	3.2	1.3
Japan	3,900	35,910	2.5	7.0
Russia	3,300	8,700	2.1	1.2
Norway	2,426	6,295	1.5	.9
Peru	600	8,625	.4	1.2
Mexico	400	65,185	.27	9.2
Canada	50	20,535	.03	2.9
Remaining countries	13,506	10,470	....	....
Totals	153,959	708,810	....	....

THE ELECTROLYTIC REFINING INDUSTRY

Some details relating to the early history and subsequent development of the electrolytic copper refining industry will be found in an article entitled "The Electrochemical and Electrometallurgical Industries in 1906," contributed by the writer to the May issue of CASSIER'S MAGAZINE. Taking the period covered by the returns for the output of raw copper, given in the preceding pages, we find that the output of the refineries has grown from 2000 tons, in 1890, to 350,000 tons, in 1905, and that the increase has been chiefly confined to the production of the American refineries. The significance of this enormous total for 1905 is realized when the nature of the electrolytic refining process is fully grasped. In its simplest form, the process depends upon the passage of an electric current between two sheets of copper suspended in a tank containing sulphate of copper in solution.

Each coulomb of electricity travels across the short intervening space separating the two metal plates carried by an atom of copper, or "ion," as it is called when thus charged with electricity. As only the copper of the metals present in the crude copper can act in this way as a carrier of the current under the conditions obtaining in the vat, the impurities of the metal are left behind, and pure copper alone is deposited on the sheet of metal by which the current of electricity leaves the vat. The process of purification is thus an atomic one,—the electricity disintegrates the crude copper atom by atom, and selects only the pure metal for building up the new sheet.

It has been calculated that there are sixty thousand millions of atoms in one cubic inch of copper. The number of atoms in one ton of copper may, therefore, best be left to the imagination.

It is certainly striking that a process of this character can be applied upon such a large scale of operations to the refining of copper, and that by it the pure metal can be produced at the rate of 7000 tons a week, or 1000 tons a day.

As stated in the article already referred to, the electrolytic copper refining process was first worked upon an industrial scale by James Elkington, at Pembrey, in South Wales, in the year 1869. The annual output of these works was about 250 tons of copper. The Mansfeld Copper Company, of Germany, followed, in 1872, with the erection of a small refinery at Eisleben, in the Hartz Mountains.

The Nord-Deutsche refinery, at Hamburg, was started in 1876, and the Communion Hüttenwerke refinery, at Oker, in 1878, while in England the refinery of Messrs. Bolton & Sons, at Froghall, in Staffordshire, dates from about the same period. In America only one refinery, that of the Phœnixville

Works, was in operation at this date.* As regards France, the writer has no reliable information, but he believes that only two of the small refineries existing at a later date were erected before 1880. The total number of electrolytic refineries operating in the year 1880 was, therefore, between six and eight, and, as already stated, the output did not exceed 2000 tons of refined copper. In the period from 1870 to 1890 the growth of the electrolytic refining industry was slow, and although many additional refineries were erected in France, Great Britain, and the United States, all were of small size and output. Since 1891, however, the electrolytic refining industry has undergone enormous expansion, chiefly in America; and the number of electrolytic refineries in existence in 1905 was stated by Mr. Titus Ulke (the statistician on the industry) to be 32, distributed as follows:—

United States	9	Proportionate output	86.50	per cent.
Germany	9	" "	2.75	"
United Kingdom	6	" "	8.80	"
France	4	" "	1.60	"
Russia	2	" "	0.3	"
Austria Hungary	2	" "		
			100.00	

To this total of 32 must be added 4 refineries which are reported to be working in Japan. The output of these is, however, not known.

The following figures, showing the output in tons of the electrolytic refined copper by the European and American refineries since 1880, are drawn from various sources, and are believed to be fairly reliable:—

	1880	1886	1891	1892	1893	1894	1895	1896	1897
America	....	5,000	22,321	45,000	51,339	56,000	77,678	110,714	111,607
Europe	2,000	6,800	7,000	....	....	....	21,249	....	....

	1898	1899	1900	1901	1902	1903	1904	1905
America	140,178	172,330	192,000	212,000	232,000	252,000	278,600	304,000
Europe	....	....	43,000	....	....	....	45,400	46,000

The British refineries have refused to publish any official returns of their production for some years, and the writer cannot, therefore, give separate figures for the six refineries located in the United Kingdom. In 1899 Messrs. Brown & Turnbull estimated the British production of electrolytic copper as equal to 15,000 tons, and it is doubtful whether this total has been increased in the intervening years.

The transfer of the chief centre of the electrolytic refining industry from Great Britain, the country of its origin, to America, is due to comparatively simple causes. The electrolytic process of refining copper is most successfully worked with ores containing considerable amounts of silver and gold. When the crude copper from such ore is treated in the electrolytic refining vats, the precious metals which are present there as "impurities" in the crude copper collect on the surface of the anodes, and on the floor of the vats, as insoluble anode "slimes" or mud. This mud is first screened to remove nodules of copper and then boiled with sulphuric acid, to remove the remaining copper and other soluble impurities. The residue is then washed, dried, and smelted with sand and soda, to obtain the silver and gold in metallic form as bullion. The value of the precious metals recovered from these slimes in many cases more than covers the cost of the electrolytic refining process, and it is Montana and California which provide the ores most rich in these most valuable impurities.

Twenty years ago these ores were smelted in America and the matte was shipped to Europe for the final refining process. To-day the position of affairs is reversed and America has electrolytic refineries sufficient in number and extent to refine three-fourths of her output of raw copper. The value of the copper contained in the vats in these large refineries is enormous, and in the Anaconda refinery alone it has been

* The Phœnixville Copper Refining Works were abandoned in 1883.—The Editor.

estimated that over £200,000 worth of copper are present in the vats, and that between £40,000 and £50,000 worth of gold and silver are recovered monthly from the slimes. In 1900 Titus Ulke estimated that 19,400,000 ounces of silver and 174,000 ounces of gold were being recovered annually from the slimes of the copper vats in America.

The cost of the refining operation has been reduced greatly in recent years in the American refineries by the introduction of mechanical devices for casting the anode slabs of crude copper and for charging and discharging the vats. The expenditure on hand labour has thus been greatly reduced, and the time during which vats are laid off for recharging and cleaning has been considerably curtailed.

The current density used for working the vats has also been greatly increased by the use of improved methods of circulating the electrolyte and by the addition of a very small percentage of hydrochloric acid to the copper sulphate solution. The increase of current density brings a great gain to the economical working of the process in its train, for the weight of copper obtained per day from each vat may in this way be doubled or trebled, with little added cost to the operation of the whole plant, save for electric energy.

The electrolytic refining process, as operated at the present time in the best planned and worked of the American refineries, is, in fact, very different from the process introduced by Elkington at Pembrey, in South Wales, nearly forty years ago. But this difference lies in the scale of operations and in the use of labour-saving appliances rather than in any change of the principles of the process. The 350 tons of electrolytic copper produced per day in the largest of the American refineries are transferred, atom by atom, from anode to cathode, exactly in the same manner, and by the same agency, as the 15-cwt. daily production of the Pembrey refinery twenty-seven years ago.

CONSUMPTION AND PRICE

The figures given earlier in this article have shown that the copper production of the world has increased nearly five-fold during the last twenty-five years, and that it has doubled within the last ten years. This enormous expansion of the copper mining industry has, however, not caused any excessive production of the metal, and during the latter half of 1905 there was a considerable increase in the price of bar copper, due to an absolute scarcity of the metal in Europe and America. The consumption of copper during the period covered by this review must, therefore, have kept fairly close to the production. If one takes the total output for the period, and ignores slight variations in stocks, one arrives at the stupendous fact that over nine million tons of copper have been worked up in the arts and industries of the world since 1880.

One may well inquire in what industries all this copper has been consumed. The idea that the electrical engineering industry is the most important consumer is hardly justified by the facts or figures; and a writer in the financial supplement of the London "Times" recently pointed out that general engineering, and especially marine engineering, accounts for a very large proportion of the annual consumption of copper. In the writer's words:—"If the man in the street or the speculator in copper warrants were to make an exhaustive examination of such a vessel (a first-class, high-speed ocean liner), he would be amazed at the quantity of copper, plain, or as brass, required about her engines, her auxiliary plant, her sanitary arrangements, her kitchens, her saloons, staterooms, and staircases, even her port-holes, rails, and scuppers."

Every branch of the building and engineering industries shares, to some extent, in this demand for copper; and in recent years the war between

Russia and Japan has led to an increased consumption of copper for military and naval purposes. Agriculture, in Italy and France, also consumes large quantities of copper in the form of copper sulphates. Add to this the special demand caused by the electrification of suburban and tube railways in London, New York, and other places, and one has some understanding of the direction in which the nine million tons of copper produced by the mines during the last twenty-five years have been absorbed in the world's arts and industries.

As regards the movements of prices, the natural increase and decrease, due to fluctuations in the demand and variations on floating stocks of the metal, have been vitiated at times by speculation in copper warrants and by attempts to corner the supplies of the metal. The most notable of these attempts was the corner of 1888, and the formation of the Amalgamated Copper Company, of New York, in 1899.

The following figures are drawn from Messrs. H. R. Merton & Company's returns, and show the average value of G. M. B.'s (good merchantable bars) for each year of the period from 1880 to 1905, these averages being based on the sale prices on the first of each month:—

PRICES PER TON OF BAR COPPER, FROM 1880 TO 1905

	£	s.	d.		£	s.	d.
1880	63	1	3	1893	43	6	9
1881	61	1	3	1894	40	2	6
1882	67	0	6	1895	42	17	6
1883	63	8	9	1896	47	4	8
1884	54	15	6	1897	49	0	10
1885	44	1	6	1898	51	7	10
1886	40	0	6	1899	72	16	6
1887	42	3	0	1900	73	10	7
1888	76	0	6	1901	67	19	3
1889	49	10	6	1902	52	13	5
1890	54	1	0	1903	57	18	8
1891	51	3	0	1904	58	14	8
1892	45	9	6	1905	69	2	6

The influence of the financial speculations in 1888 and in 1899 is clearly shown in the diagram on page 460, in which the preceding figures are plotted as a curve.

The striking rise which has marked the close of 1905 has been attributed by some, interested in the copper market, to further financial speculations, but there is no clear evidence that it is due to anything beyond natural causes. The engineering industry, both in the general, electrical, and marine departments, has been unusually busy in 1905, and the order books of manufacturers are well filled for 1906. The demand for copper has, therefore, been unusually brisk, and towards the end of 1905, when a scarcity of the metal became noticeable, buyers became panic-stricken and rushed to buy copper warrants to cover their future requirements in a somewhat precipitate manner. The natural result was a marked rise in price, and the level of 1899 was again nearly touched. The purchase of copper for coinage purposes in China during 1905 has also further aggravated the situation, the writer of the "Times" article already referred to estimating this at 60,000 tons.

The position as regards the future is somewhat uncertain. Prophecy would be out of place in an article that is mainly a record of facts and figures. That the production of copper will increase for some years, in sympathy with the demand, is evident. Will old mother earth, however, be able to continue for any considerable length of time supplying us with copper at the rate of 700,000 tons per year; and if the supply fails, what metal will take its place?

ADVERTISING IN CONNECTION WITH ELECTRICITY SUPPLY

THE VALUE OF OBJECT LESSONS IN THE USE OF ELECTRICITY

By Arthur A. Day, of the Corporation Electric Works, Bolton, England

Mr. Day's remarks are supplemental to the several advertising suggestions made in some of the preceding articles of the "Electric Central Station Business-Getting" series which began in the April number of this magazine. They call attention particularly to the great advertising value of object lessons in the various applications of electricity,—exhibitions, in other words, instituted by the central station or by the municipality which has current for sale.—The Editor.

IN all branches of business, advertising has come very prominently to the front during the last few years; many large businesses have been built up by advertising pure and simple. With the many advantages appertaining to the use of electricity for heating, light, and power, it seems a pity that advertising in connection with such a supply has not been more freely entertained, as there can be no question that the prospective consumer, if he became aware of the advantages of such a supply, would very soon become a consumer.

I believe one reason why advertising in connection with electricity supply has been neglected is that the supply is sometimes in the care of a municipality and is practically a monopoly, and that the advantages of electric supply have alone been relied upon to bring in business; as a matter of fact, in most cases I think it can be said that the business has come on rather faster than it could be properly dealt with.

Now, however, the case is very different. Electricity has to be pushed if it is to go, because the advance in the application of other illuminants has, of recent years, been very considerable. I do not think there is any doubt that the electric supply for illuminating purposes, and also for power and heating, will eventually prevail, because the advantages are mainly on the side of electricity; but whether the general adoption of electricity for such purposes will be rapid now depends more than it ever did upon the question as to whether the consumer is made fully aware of the advantages claimed.

As to the methods of bringing the advantages of electric supply for all purposes before the public, there are many, but I think it must be generally admitted that circularizing prospective consumers is not of any great use. It is sometimes difficult to explain electrical matters to a consumer even by interview because of the necessity of using technical terms; to send to him a circular, therefore, which is only putting the same matter into writing, has all the disadvantages of having to be technically worded, and the further disadvantage that there is no one by to explain any difficulties. Personally, I think that circularizing is of very little use.

Personal canvassing comes next; that is considerably better than circularizing, but it should be done by a technically competent person,—one who is fully qualified to answer all questions on the spot, and if the neighbourhood dealt with is one where there is a reasonable chance of getting a substantial number of consumers I think it is very likely that such personal canvassing would pay.

The best of all methods, however, in my opinion, of bringing the ad-

vantages of electricity to the notice of the public is to give a practical demonstration in the shape of an exhibition. If a man can see a process or an apparatus, as the case may be, in full work, see how simple it is, and the advantages which it possesses, he requires convincing only on the question of cost, and even in some cases not too much convincing on that point, to become a user of electrical energy. Electrical exhibitions, even if they cannot be carried out on a large scale, interest everyone, and if such an exhibition could be made permanent, although the exhibits might be changed, I think it would be very beneficial.

The real facts of the case where electricity supply does not appeal to the public is that the prospective consumer either fears the expense or has a mysterious feeling that there is something about the supply which he does not understand, and which, perhaps, he had better leave alone. Nothing, to my mind, would be more likely to overcome this feeling, and, at the same time, put him in the way of the advantages to be derived from using electricity, than a permanent exhibition which would enable him to see practical operations carried out before his eyes. This kind of advertising, I believe, would lead to very good returns.

Before any method of advertising is adopted in connection with any electricity supply, the person, or persons, governing such supply should be quite sure of being prepared to sell current at a rate which would make its use distinctly advantageous to the consumer. Some towns manage to supply a fairly large amount of electricity, but, in my opinion, they would supply a still larger amount and be far more prosperous and reduce the cost of supply if, before advertising, the responsible person ascertained what charge it is necessary for him to come down to before he can make the supply reasonable. If he puts the price of supply at a figure which he knows will show a consumer an advantage, then exhibits before him apparatus at work such as would be beneficial in his business, whether it be for lighting, heat, or power, there can be very little doubt that the consumer would, sooner or later, adopt electricity to his own benefit and to the benefit of the electric supply company.

Current Topics

THE interest now being displayed so widely in the study of combustion economy is one of the most gratifying signs of the times. The growing importance of the subject is reflected in an increasing number of papers by engineers before the various technical societies. It is only recently that the engine room side of the power plant absorbed almost all the attention of those who were trying to secure larger results per pound of fuel consumed, and the lack of adequate facilities for the analysis of boiler performance in comparison with the apparatus available for the study of steam engine and dynamo cperation, coupled with the personal discomfort often attending work in the boiler house, militated against a persistent campaign against over-consumption of fuel. Much still remains to be learned about combustion, but considerable progress has been made of late in the direction of experimentally determining the best operating conditions of individual plants.

COMBUSTION and the transmission of heat cannot go on at one and the same time and place with economy. Experience shows that the combustion of the fuel should be as complete as possible before the hot gases strike the tube spaces of a boiler. Excessive draught tends to accelerate the movement of the gases through the furnace and boiler, and as the speed of these is often as high as 40 or 50 feet per second, it is easy to see why flaming so frequently occurs in the latter passes of the boiler before the uptake is reached. It has lately been suggested that by the use of forced draught the pressure of air below the bed of fire can be so regulated that the draught above the fire is very small,—just enough to carry the products of combustion through the tubes and flues. The reduction in the velocity obtained ought in every case insure a much better combustion before the gases reach the tubes.

THE method of adding coal to the fire is of great importance, and the opinion is rapidly gaining ground that the addition of small quantities of coal regularly is the only certain way of securing that evenness of combustion which insures the best results. Although it is generally conceded that an expert fireman can equal the work of an automatic stoker if he is able and willing to work hard during his entire watch,

the stoker accomplishes some results which are impossible under hand-fired conditions. It introduces coal into the furnace without admitting cold air; it helps to burn the coal in such a way that tne volatile gases are thoroughly consumed, giving up to the boiler heat which is, to a great extent, lost in hand-fired practice; it keeps the fire automatically sliced without admitting cold air, allows it to be cleaned without loss of efficiency or capacity, and can in some cases be adjusted to control the amount of air and coal in such a way that they always bear a fixed relation to each other, irrespective of the rating at which the boiler is being operated. One cannot, of course, assume that every installation needs an automatic stoker, but there is no question that economy of fuel depends in a marked degree upon an intelligent adjustment of the rate and volume of fuel and air supply.

WITHIN the last two or three years so much attention has been given by progressive industrial organizations to methods of bettering the working, and even the living, conditions of wage-earners in their employ that the work which has been accomplished in the interests of salaried employees has frequently been overlooked. It is not an easy task to draw the line between salaries and wages, but in a rough sort of way it may be taken that an employee whose rate of compensation is fixed by the year or month usually falls into the salaried class in the auditor's records, while he who works by the hour, day or week is ordinarily considered a wage-earner. There are numerous exceptions to such a classification, but it suffices to define in the rough the class of employees referred to in these comments. The executive officials of many industrial establishments now realize that the good feeling and loyalty of the salaried employee is an asset of considerable value. As a general rule, the working conditions which surround this class of men are pleasanter than those under which the wage-earners labour, so that it has not been found necessary to institute the same sort of betterment work as in the case of the men who bear the brunt of the production in their contact with machinery and raw materials. In most manufacturing companies the office work is, on the surface at least, performed under easier conditions and better surroundings than are possible in the factory; the hours are generally shorter, the personal comfort is greater, and the regulations are more elastic. The work itself may be far more exhausting in some cases than the wage-earner's duties, but on the whole there are less physical needs to supply to the salaried man than to his wage-earning brother.

THE betterment work which has been done for the salaried man has therefore proceeded along the lines of his permanent intellectual and personal improvement rather than in the direction of improved sanitary facilities at the office, shower baths, recreation rooms, and the like. A gratifying tendency to establish technical reading rooms and libraries has been noted in industrial circles; improvements have been brought about in regard to luncheon problems, in opportunities to invest money in the company's care, to build individual homes with the company's aid, to purchase the company's products at reduced rates, to procure life insurance under almost nominal conditions of cost. In these and other similar ways efforts are being made to foster esprit de corps. Attempts to promote good-fellowship between department heads have resulted in much better co-operation during working hours, and frequent meetings for round-robin conferences between the management and responsible subordinates have at times

proved of inestimable value. The offering of free legal advice by the law department, the gift of money to benefit associations, the sale of supplies, and the offering of free telephone service homeward to employees on distant trips are fair examples of the tangible ways in which corporations are interesting themselves in the salaried man's personal prosperity It is well to think of such things as this when the industrial pessimist has the floor.

IN many manufacturing processes it is essential that the materials under treatment be wet before they are finished, and on account of the uncertainties and difficulties of natural drying, mechanical draught has been applied to this work with particular success. Very frequently neither the space nor the time is available for drying the materials by exposure to the sun and air, although this method is usually thoroughly successful under favourable conditions. As a rule, goods can be rapidly dried if they are exposed, on racks in a room or compartment, to currents of heated air. The rate of drying depends upon the temperature of the air, and by varying this the absorption power of the air can be controlled within wide limits. Thus, air at 82 degrees F., with moisture at 90 per cent. of saturation, has its absorption power more than doubled when it is heated to 110 degrees, since the saturation is reduced to about 42 per cent. by the elevation of temperature. The flexibility of mechanical draught is illustrated in its application to artificial drying. A compact motor or engine-driven fan may be employed to force the air through a system of live or exhaust steam coils, and thence through appropriate ducts to the drying room. The sectional form of the heater makes it adaptable to all sorts of locations, and by varying the speed of the fan, the steam pressure, the number of coil sections in service, or the duct cross-section, the drying may be easily adapted to the work in hand, without danger of injuring delicate work by extremes of temperature.

WHILE on the subject of mechanical drying, it may not be amiss to add a few words on the summer ventilation and cooling of laundries. This is one of the serious problems of laundry management during the heated term. Air-cooling devices are apt to be complicated and expensive and in the end are not much better than positive means of furnishing air. It is air movement and circulation which bring about the beneficent results desired. Everyone recognizes the peculiarly depressing and exhausting effects of a stagnant atmosphere. When we add to this the excessive humidity of the average laundry, we have a combination that is almost unbearable. When the air outside is still, or when laundries are so located as to absolutely prevent a free natural circulation of air through the rooms, it is evident that artificial means must be introduced for the purpose. The constant change of air thus brought about serves the double purpose of ventilation and of cooling, although the latter effect may be due fully as much to air movement as to reduction in temperature. The effect of air movement is to constantly supply dryer air, which greedily absorbs the moisture given off in perspiration, and that arising from the work in the room. For the ordinary purposes of ventilation in winter weather an air change in the average laundry, which completely removes the air once in ten or fifteen minutes, would give as good ventilation as is assured in the best equipped schools and public buildings, but this volume is entirely ineffectual to meet summer conditions and to offset the effects of high humidity. For summer ventilation the maximum time for air change should not

exceed five minutes, and it may well be brought down to one or two minutes. This, of course, means large volumes of air, whose movement it would be utterly impossible to secure by natural means. Take a room 30 feet by 40 feet by 10 feet, for instance, and it will be seen that to change the air once in two minutes requires no less than 6000 cubic feet of air movement per minute. To secure this movement the fan-blower or propeller wheel is the only economical device. It may thus be utilized either for the purpose of exhausting the warm and moist air from the room, or for discharging cool air into it. The method chosen must depend largely upon the conditions.

From Other Points of View

Objections to High Crane Speeds

Harry Sawyer, before the American Foundrymen's Association.

THERE is at the present time something of a demand for excessively high speeds, and the motives of the manufacturers who advise against them are sometimes misunderstood. It is not that the problem presents any difficulties from the manufacturer's standpoint. He may prefer to furnish a standard article, from considerations of cost and delivery, but oftener he is considering the direct benefit to the customer and the indirect benefit to himself. The manufacturer and user may recognize the same advantages and disadvantages, but from their different standpoint they do not see them in the same proportion.

The one advantage sought in high speeds is a saving of time, but this is often overestimated. Take, for example, a 10-ton crane with full load speed of 20 feet per minute. We may assume that the average load will not be more than one or two tons, that the average speed for such load will be 30 feet per minute, and that the average lift is 5 feet. Allowing 50 per cent. more time for acceleration from a state of rest, and we find the time for an average lift to be fifteen seconds.

If the speed of a hoist were doubled, it would at first appear that one-half of this time, or seven and one-half seconds, would be saved. If twenty lifts were made per hour, the result would be a saving of only about 4 per cent. of the time. When it is remembered that many of the lifts must be very slow, regardless of what the crane is capable of doing, and that traverse movements are usually started as soon as the load is clear of surrounding objects and before the hoist movement is stopped, the actual saving is reduced to a very inconsiderable amount of time.

Where a large floor area is covered, a greater saving can be made by increasing speeds of horizontal movements, but the swaying of load which results from high speeds and sudden starting and stopping, sets a limit to the saving that can be made in this direction.

Two objections may be offered to excessively high speeds. First, the accidents that are likely to result from putting a high-speed crane in the hands of an incompetent operator often cause the loss of much more time than is saved by the higher speeds, and greatly increase the cost of repairs. Second, if the crane is not usually run at full speed, there is a constant loss of power in the rheostat, and unnecessary wear and tear on the controller parts, both of which cause expense and loss of time. The above comparisons apply with the most force to cranes in foundries, and with least force to cranes in mills where much higher speeds are necessary and practical.

Data on Fuses

From "The Electric Journal"

ONE of the principal features of the fuse is its overload time element. Before a given current will heat up the fuse metal to its melting temperature a fixed time must elapse. This time lag, as it is commonly called, rapidly decreases as the current increases.

There is a common impression that fuses and overload circuit breakers have practically the same characteristics, though such is not the case. The overload circuit breaker depends for its operation upon the quantity of current, while the blowing of a fuse is dependent both upon the quantity of current and upon the time during which it is applied. The circuit breaker will open immediately at any overload in excess of its setting, but will not operate at any smaller current, no matter how long continued. Standard fuses, on the other hand, will operate, in time, at as small an overload as 25 per cent., and will open in a proportionately shorter time with greater overloads.

In determining the proper size of fuses to protect any apparatus, the overload time element should be considered in connection with the smallest current likely to prove dangerous. The low cost and the overload time element of the fuse render it particularly suitable for the protection of motor circuits, as it will carry a certain overload for a short time, but will open if the overload continues.

For alternating-current motors, taking a starting current much more than the full-load value, fuses which would carry the starting current would not give much protection except against a short-circuit. In order, therefore, to afford adequate protection, a second set of fuses is necessary. These fuses should be switched into the circuit after the motor has come up to speed. When thus used they may be of suitable capacity to give much better protection to the motor.

The use of two enclosed fuses in parallel is not advisable unless sufficient resistance is placed directly in series with each fuse to render the contact resistance of the fuse negligible. Fuses have such low resistance that equal resistances in the two branches cannot be insured except by the arrangement just mentioned, as the resistance of the contacts would be proportionately large. When branches of unequal resistance are in parallel the two fuses do not carry equal currents, and are likely to open the main circuit at a current less than their combined carrying capacity.

The various types of open-link fuses which have been in common use for a number of years are objectionable, as the fuse metal is exposed, and there is a considerable flash and throwing of fuse metal when the fuse operates under heavy overload or short-circuit. This has

made it necessary to enclose such fuses in cabinets, except when installed in places where the flash and hot metal can do no harm. Also, open-link fuses cannot be very accurately rated on account of the exposure of the fusible strip. It was to overcome these objections that the enclosed type of fuse was developed.

The enclosed fuse consists essentially of a fusible element enclosed within a tube filled with a material to exclude the air and to facilitate the opening of the circuit when the fuse blows. Suitable terminals are provided so that the fuse may be mounted in a fuse block.

Complete lines of enclosed fuses were developed by several manufacturers, each make of fuse having different dimensions from those of other makes. This often made it very difficult to obtain fuses for renewals, as the corresponding capacities of the different makes did not have the same dimensions, and hence could not be used in the same fuse block. On this account dangerous substitutes for fuses were frequently used. Furthermore, enclosed fuses were not uniformly rated, as some makes were rated at about their maximum carrying capacity, while others were rated at about 80 per cent. of this amount, making a difference of 25 per cent. in the carrying capacity.

So much confusion resulted from the lack of uniformity of the commercial types of fuses that finally a conference was held between the representatives of the Underwriters National Electric Association and the fuse manufacturers, for the purpose of adopting standard requirements for enclosed fuses.

Standard dimensions and test requirements were prepared for 250 and 600-volt fuses. These requirements are given in the 1905 edition of the National Electric Code, under Rules 52 and 53. Fuses constructed in accordance with the standard are known as National Electric Code Standard fuses. The dimensions of the fuses have been carefully worked out, and are as small as it is safe to make them. Standard fuses are now made by all the principal fuse manufacturers, and are interchangeable in all National Electric Code Standard fuse blocks of corresponding capacity. The use of fuses of special dimensions, and particularly those smaller than the standard, should be discouraged.

Much credit is due to the members of the Underwriters committee for their work in the preparation of the standard, and to the various fuse manufacturers, who gave their hearty co-operation.

The standard divides enclosed fuses into classes, according to the voltage and ampere capacity, and specifies the dimensions for each class, so that a given fuse can be used only in a fuse block of its class. The fuses are rated so that they will carry 10 per cent. overload indefinitely, and will open at 25 per cent. overload.

Metallic Filaments for Electric Lamps

J. Swinburne, Past President Inst. E. E., in "The London Times" Engineering Supplement.

IT is now quite well known that several metals are infusible enough to serve as lamp filaments if they can only be made into that form. The infusibility of the metal is the chief obstacle to its being made into wire, for such metals are generally obtainable only in a fine powder by reduction from the oxide, or in partially fused lumps which contain carbon, and are not in a condition suitable for wire drawing.

Dr. Hans Kuzel has invented a process by which the most refractory and obstinate metals can be made into filaments. It might be said that there is little difficulty in making a filament from a metallic powder by mixing it with an agglutinant and squirting it. Anyone who has tried squirting such things as powdered silicon, tungsten or molybdenum will

realize the difficulties. Tungsten powder, for instance, can be squirted in rods about a millimeter in diameter; but these would be of no use for resistances in thousands of ohms. These powders, made into pastes and squirted, generally pack, and only water comes through the nozzle. Squirting can be greatly facilitated by the use of gum tragacanth. It would be interesting to know who first thought of tragacanth in that connection. A comparatively small percentage of the population of the globe knows anything about tragacanth or its ways; and a still smaller percentage is interested in squirting filaments; so that the chances that any one person, knowing about tragacanth and wanting to squirt filaments, should realize that tragacanth would help him are very small indeed. I believe the use of this gum was due to Farnejehlm,—one of the early workers in incandescent gas light. He made mantles of little baskets of squirted magnesia.

Kuzel is generally supposed to have invented a tungsten lamp. His invention is really a method of making lamp filaments of any suitable metal; and he appears to have chosen tungsten as the most suitable. He makes what he calls "hydrosols, organosols, gels or colloidal suspensions." It will be remembered that Bredig prepared what is called "Colloidal" platinum by making an arc between platinum electrodes under water. Apparently the platinum vapour condenses in the water in the form of very fine particles, and the resulting liquid is said to contain colloidal platinum. Kuzel makes colloidal chromium, manganese, molybdenum, uranium, tungsten, vanadium, tantalum, niobium, titanium, thorium, zirconium, platinum, osmium, iridium, boron, and silicon; I am quoting from his patent specification. No doubt Kuzel has experimented on all these. Of course, I have not.

Whether such a process really gives metal in a colloidal form is a matter rather of scientific than of commercial interest. The exigencies of journalism do not give a writer time to look up the scientific literature of a subject. This is a great advantage from his point of view, as he can be inaccurate with a clear conscience. I have, therefore been unable to refer to Bredig's paper; but by a "colloidal" substance is generally meant such a substance as gelatine, which appears to exist in solution in large particles, if such an expression can be used. What is known as "colloidal gold," on the other hand, may be merely gold in very small pieces floating about in a liquid. The particles are too small to be seen properly through an ordinary microscope; but recently an advance has been made in microscopy by means of which the existence of small particles in colloidal gold solution can be seen. I am sorry I cannot remember the name of the inventor of this system; one of his microscopes was shown at the Physical Society lately by Messrs. Zeiss or Beck, with some colloidal gold for examination. It may be said that if the gold is in small particles it would settle, and it would not pass through filter paper. But fine precipitates will pass through filter paper. Ink, or, better still, India ink, is a good example. If ink is examined under a microscope it will be found that the particles are all moving about with immense activity; and this is probably the reason why they do not settle. Very little work has been done in studying this "pedesis" or "Brownian" movement, as it is called. The addition of certain salts to water containing finely-divided ferric oxide, for instance, stops the rapid motion, and the particles group themselves together and descend as a flocculent precipitate. Bredig urged that his colloidal platinum acted as an inorganic ferment in many cases. It is quite possible, however, that the fineness and movement of the particles had much to do with it, and that the

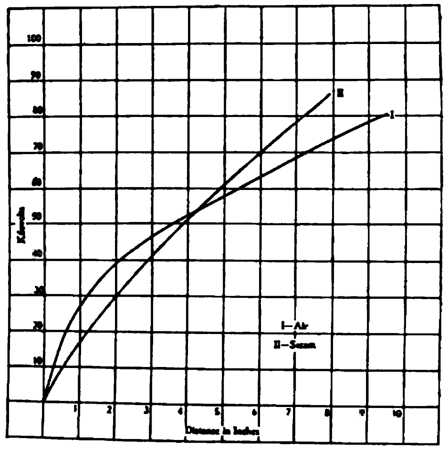
"poisoning" of the platinum was intimately connected with the stopping of its pedesis. Whether Kuzel's finely divided metals should be called colloidal suspensions, gels or hydosols is for the present purpose a side issue. The fact appears to be that he has invented a most ingenious way of converting metals into a fine, smooth paste, in which the particles are so exceedingly small that very fine filaments of paste can be squirted. These filaments are then heated electrically until they practically fuse together.

If this invention works practically, as there is little doubt it does, it opens a very large field, because it puts the inventor in the position of being able to make lamp filaments of any metal he chooses. It is simply a matter of choosing one which has a high melting point, and is otherwise convenient. Of course, the melting points of the very refractory metals are not yet ascertained. It has been known for a long time that tungsten is very infusible; and it was considered an achievement when it was first fused in the electric furnace some fifty years ago. The metal is otherwise so unpromising physically that to make from it a lamp filament is a very remarkable triumph over the apparent obstinacy of inanimate things.

Effect of Smoke on Trolley Wire in Joint Operation

From the "Street Railway Journal"

APROPOS of the general increase in the outcome of the many proposals now under way looking to joint operation of electric cars and steam locomotives over the same tracks, there has been considerable discussion as to whether, if high-voltage trolley wires are placed over the tracks of railroads using steam locomotives, and particularly at such places as in tunnels and under bridges, there might be dielectric discharges from the trolley



GRAPHIC REPRESENTATION OF TESTS TO DETERMINE THE RELATIVE TENDENCIES TO DIELECTRIC DISCHARGES IN ORDINARY AIR AND IN STEAM

to the locomotive and ground, caused by the steam and smoke of passing locomotives acting as conducting mediums. To determine the actual properties of steam and smoke under these conditions and to find out the likelihood of trouble from this source, certain tests have recently been made, and are described by S. M. Kintner in a recent issue of "The Electrical Journal." Mr. Kintner states that in the first test two terminals were placed one above the other and arranged so that the space between them forming the discharge gap could be varied at will. The terminals were ½ inch in diameter with spherical ends, and were so mounted that jets of steam and smoke could be projected around the terminals in a direction parallel to their axis of support.

In the first test a column of steam was projected across the gap between the two terminals. The steam was purposely made very moist by passing it through a long line of pipe, so that it lost a large quantity of heat before arriving at the gap. The results of this test are shown in the curves on the accompanying diagram. In summarizing the results the author points out that the strik-

ing distance, or distance at which current will jump the gap, is greater for a given voltage in air than in smoke for voltages below approximately 55,000, but that at this point the curves cross each other, and it requires a greater voltage to jump a given gap in steam than in dry air. The jumping distance in air, as plotted in this curve, was obtained by measurements taken at the time the curve for steam was determined, the same terminals being used and the points checked several times, so that it seems certain that the values are relatively correct. During the test with steam the terminals were saturated with moisture to such an extent that the water dripped from them freely. No perceptible change was noted, however, when the steam was somewhat drier.

The next test was made to determine the conductivity of smoke and cinders. The terminals were immersed in a dense volume of smoke produced by building an intense fire in a small stove. After a hot bed of coals was obtained some fresh coal, containing considerable dirt, sulphur, etc., was thrown on to the fire to prevent perfect combustion and produce large quantities of very dense black smoke. It was in this case impossible to maintain constant conditions through a sufficient period to obtain a curve, but a number of observations were taken which indicated that the striking or jumping distance through dense smoke was not materially reduced from that of the steam or air in the previous test.

One set of readings was as follows:—

TABLE OF VOLTAGE-STRIKING DISTANCES IN DENSE SMOKE AND STEAM

Voltage	Distance in Inches
14,000	1.375
25,000	2
35,000	3
42,000	3.75

From these tests the conclusion is made that with a reasonable factor of safety, of possibly six or seven, over the dielectric strength of air, no difficulty will be encountered through steam and smoke from locomotives attracting current from an overhead trolley wire.

The Prevention of Engine Wrecks from Cylinder Water

From "The Engineering Record"

MANY serious accidents to engines are caused by water finding its way into the cylinder from the steam pipe when the latter is not properly drained, and even from the boilers themselves when these, for any reason, throw it off in the process of priming. Water is also drawn back into the cylinder in the case of condensing engines through failure of the condensing apparatus. These accidents do not occur without good reason, for when the plant is in operation and all its parts are in proper condition, the chance of trouble from this cause is extremely remote. It is the vigilance of the engine-driver and fireman upon which dependence must be placed for the prevention of injury. Instances of this sort have been often mentioned where engines have been broken down as a result of the introduction of water into the cylinder, and, as everyone who has had experience in the matter knows, the effect is liable to be disastrous. It is not merely a few bolts which break or some minor part which becomes deranged, but some vital piece in the structure is the thing which usually gives way, involving the stoppage of the engine and the work which it drives for days or weeks at a time, until the necessary repairs can be effected.

It seems a pity that accidents which from one cause or another are so liable to occur, and which are attended with such important consequences, cannot in some way be made less disastrous. With so much at stake, designers of engines might bring about some system which should lessen, if not wholly over-

come, the evil results following the introduction of water into the cylinder. The engineer maintains that he cannot supply in his design the brains and vigilance which the engine-driver lacks. He claims that it is one of the exigencies attending the generation of power that a charge of water may get into the cylinder, and when that happens the only thing to do is to accept the consequences, however serious they may be. This, however, is not what the power-plant purchaser requires from engineering. He states the conditions, and what he desires of the engineer is that the iron and brass shall be so put together that the conditions will be met, one of the most important of which is that his plant shall be kept running and turning out regularly the allotted quantity of production.

Considerable improvement has been made of late years, it is true, with a view to providing against injuries of this kind. Cylinders are fitted with relief valves, set at a point slightly above the highest working pressure, and made of considerable size, so as to provide a means for the escape of water if it should accumulate in excessive quantity. They are applied to the sides of the cylinder, one at each end, and with this location it will be seen that they can be made of only limited size. Experience has shown that this plan does not secure a sufficient opening to discharge the large volume which must be taken care of if the water comes over at all.

In the case of single-acting engines, the injury produced by accidental accumulations of water can be greatly lessened by making the cylinder head of such form that when a dangerous pressure is brought to bear upon it, the breaking strength is exceeded, and the central portion of the plate gives way, and allows the water to discharge through an opening, nearly, if not quite, the full size of the bore of the cylinder. Such an arrangement is impracticable on the ordinary double-acting engine, owing to the attachment of the framework of the engine to the opposite end of the cylinder. The same idea, however, might be carried out by providing a secondary cover of a diameter considerably less than that of the cylinder bore, the cover being designed so as to give way by breakage when a dangerous pressure is reached and thus provide a relief opening of much greater size than could be had by the common practice. There may be other methods of accomplishing the same end, but it must be admitted that some better means of meeting emergencies in the running of engines due to water in the cylinder should be provided. There is something incongruous in designing some detail of a cylinder so weak as to invite breakage when the pressure reaches a certain limit, but if this serves as a safety valve and prevents the wrecking of the main structure, it is certainly a wise provision.

Some Export Trade Humbugs

Edward Neville Vose, before the New England Cotton Manufacturers' Association

THE commonest type of export trade humbug is the syndicate agent. It is by no means unusual for a group of manufacturers in closely related lines, or perhaps residing in the same city or belonging to the same club, to form a little syndicate or organization for the purpose of sending a salesman abroad to represent them all jointly. This plan is proper and entirely practicable. The humbug who seizes upon this idea reverses it. Instead of the manufacturers who form this "syndicate" working together and hiring the foreign salesman who seems to them most capable, the agent makes his own arrangements with each manufacturer separately. Instead of confining the syndicate to four or five closely related lines,—such as clocks, watches, silverware, and jewelry,—he calls upon anybody

he thinks he can get and cheerfully undertakes the representation of watches, steam engines, hair restorers and sulky plows, and as many other lines as he can run across. While usually asserting that he intends to have at most only ten firms in his syndicate, the agent often secures that number in a single city and then goes on for more, telling each new victim that his firm is the last one needed to complete the enterprise. As the agent has no intention of so much as attempting to secure business for his clients, it is easy for him to make big promises. It is the folks who intend to keep their word who are hampered by having to keep within the prosaic limits of probability. The thing to do when such syndicate agents come around is simply to put their statements to the test, insist on knowing the name of every firm composing the syndicate, investigate the agent's credentials and antecedents, and, in a word, treat the whole proposition just as you would if it related to domestic trade instead of foreign. There is no hocus-pocus about export trade that prevents the ordinary rules of business and of common sense from being applied to it.

An ingenious variation on the syndicate idea is that of the species of humbug who proposes to sell the manufacturer's goods strictly on a commission basis with a small salary to cover expenses. As the salary is to be deducted from the amount of the first order, and is not due if there are no orders forthcoming, the manufacturer considers himself quite safe in signing this contract, and cases have even been known where men who have been victimized by the syndicate game have been victimized a second time by this clever and apparently innocent scheme. What happens, however, is this. The swindler disappears with his contract in his pocket, and for a year or so no more is heard of him, and he is well-nigh forgotten. Then an order is received from some distant point through his New York representative. The goods are shipped as directed, but instead of a remittance the manufacturer receives a neat little "statement" showing that his account with his forgotten "agent" stands somewhat as follows:—

To twelve months' salary at $50 per month, as per contract	$600
To commission on sale at 10 per cent	60
Total	$660
By merchandise, as per invoice	600
Balance still due	$60

While the cool request for another sixty dollars or so is usually ignored, the manufacturer really has no redress in a case like this. The goods are beyond recovery, and are, of course, sold before this "Statement" is ever rendered, while if the humbug were caught,—which is also difficult,—his "contract" would probably protect him against a criminal charge, and his utter lack of resources renders a civil suit useless. The only way to avoid such expensive experiences is to act toward such propositions as toward syndicate schemes,—rigidly investigate everything, and reject absolutely those that show the slightest ground for suspicion.

The very latest wrinkle in the line of export agent humbuggery was brought to my attention only a few months ago and hailed from Egypt, although I have since learned that a somewhat similar scheme has been tried elsewhere. A firm in Egypt made a contract with an American manufacturer whereby it was granted the exclusive agency of the manufacturer's goods for that country, the contract to run for two or three years unless formally terminated. As no orders were ever received, the American concern decided that its agent had gone out of business or was unable to effect any sales, and allowed some of its products to go to another Egyptian firm. The "exclusive agent" seems to have been waiting for this very thing to happen, for he immediately pounced upon the manufacturer with a suit for 50,000 francs damages for breach of contract. The

case went to the plaintiff by default, and he secured the full amount demanded and costs, together with a court order authorizing him to seize the defendant's goods or property in any part of Egypt. The result of this procedure was not so serious in point of actual loss, since the goods thus seized amounted to only a few hundred dollars in value, but this manufacturer now finds himself barred out of the Egyptian market indefinitely, while his competitors may be getting a firm foothold there. The same scheme in France or Mexico or any large buying market might result in very heavy loss both in confiscated goods and in trade. It is rarely worth while to contest such cases, since local courts will almost invariably favour the plaintiff, and foreign lawyers are usually troublesome and expensive. It is extremely difficult to prevent a few packages of one's goods from getting into a country tied up by such an exclusive contract, even when the utmost care is taken to do so, since merchandise often travels by roundabout channels.

A most pestiferous colony of humbugs once established itself at Amsterdam and preyed upon American manufacturers for a number of years until finally suppressed by the Chamber of Commerce of that city and the post office. These rascals, who turned out to be few in number, fixed up letter-heads representing a great number of fictitious firms, and wrote around to manufacturers whose names they secured from advertisements in export papers, and even from the consuls.

To each one they represented that they were about to open "spacious warerooms," and solicited a few "samples" of his products, to be duly installed therein in a place of honour. The fountain pen manufacturer was to send half a dozen or so of his best gold-mounted fountain pens, the carriage maker one or two carriages, and so on. No article was too large and none too small to merit a place in this magnificent emporium. Many manufacturers were victimized, particularly those making specialties of no very great value, such as washing machines, kitchen utensils, etc. It was simply a case of petty larceny. No orders ever came, and when investigation was set on foot,—too late, as usual,—it was found that no wareroom existed, the firm having only a letter box, which had some time since been given up. This type of humbug still continues to flourish here and there, though no longer at Amsterdam. Not long ago I was shown twenty letters in French from a firm in Egypt addressed to as many different American manufacturers and asking for samples of all degrees of costliness, from a patent scalp brush to a stationary engine. It was simply the Amsterdam humbug in a new locality. The only way to avoid such pitfalls is either to refuse samples to all foreign buyers unless paid for in advance, or take such steps to ascertain the responsibility of the parties asking for them as ordinary prudence would seem to dictate.

PHOTO BY STEIN, MILWAUKEE

HENRY LATHAM DOHERTY

SEE PAGE 566

CASSIER'S MAGAZINE

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ENGINEERING IN THE PIKE'S PEAK REGION

By John Birkinbine

THE one hundred and four thousand square miles of plains and mountains, sombre canons, and snow-clad peaks within the boundaries of the State of Colorado, include numerous scenic attractions and many impressive engineering achievements which have been so well advertised by thousands of tourists, or by railway literature, that we hardly appreciate that the State, on July 4 of this year, celebrated its thirtieth anniversary of American Statehood.

Five years ago, President Roosevelt, in an address at Colorado Springs, said:—"With the exception of the admission to Statehood of California, no other event emphasized in such dramatic fashion the full meaning of the growth of our country as did the incoming of Colorado. * * * The westward spread of our people across this continent has been so rapid, and so great has been their success in taming the rugged wilderness, turning the gray desert into green fertility, and filling the waste and lonely places with the eager, thronging, crowding life of our industrial civilization, that we have begun to accept it all as a part of the order of nature. * * *

"There was scant room for the coward and the weakling in the ranks

THE RACK RAILWAY UP PIKE'S PEAK

of the adventurous frontiersmen—the pioneer settlers who first broke up the wild prairie soil, who first hewed their way into the primeval forest, who guided their white-topped wagons across endless leagues of Indian-haunted desolation, and explored every remote mountain chain, in the restless quest for the metal wealth.

"Behind them came the men who completed the work they had roughly begun; who drove the great railroad systems over plain and desert and mountain pass; who stocked the teeming ranches, and under irrigation saw the bright green of the alfalfa and the yellow of the golden stubble supplant the gray of the sage-brush desert; who have built great populous cities —cities in which every art and science of civilization are carried to the highest point—on tracts which, when the nineteenth century had passed its meridian, were still known only to the grim trappers and hunters and the red lords of the wilderness with whom they waged eternal war."

In the corner of the original Louisiana purchase, defined by the Arkansas River on the south, and the crest of the Rocky Mountains on the west, are many of Colorado's famous natural features, and instances of mining, transportation, and industrial development, descriptions of which would fill many pages,—a development which seems the more remarkable considered in connection with the public recognition of the discovery of Pike's Peak, in 1806, by the centennial celebration at Colorado Springs during the month just passed.

The city of Denver with its 170,000 inhabitants, with water-supply, gas and electric light, sewers, trolley systems and other public utilities, its 75 miles of paved streets, flanked with substantial buildings and comfortable homes and 150 churches; its extensive industries and comprehensive railroad facilities, is a marvel when we recall the fact that it is but half a century since the site of this progressive municipality, this commer-

THE PIKE'S PEAK RAILWAY.—CLIMBING THE GRADE NEAR THE SUMMIT

SNOW OBSTRUCTIONS ALONG THE LINE

cial, industrial and railway center, was recognized as Auraria on Cherry Creek. Then a few crude buildings cared for the limited population and for those who made tedious overland journeys of 500 miles from the banks of the Missouri River,—a journey which is now covered in comfortable cars in a few more hours than the days formerly required by stage coaches with relays of horses.

Pueblo, with its great iron and steel plant, its smelters and its busy population of 40,000, is another surprising evidence of progress, for among its business men, still active, are some who lived and traded in the cluster of adobe huts which received the Spanish name for village, and whose protecting stockade was a welcome refuge for those who traversed the historic Santa Fe trail, watching day after day the white dome of Pike's Peak, which on each

THE RACK RAILWAY UP PIKE'S PEAK. BEFORE REACHING THE SNOW LINE

succeeding morning seemed no nearer than on the previous day.

Colorado Springs, a later settlement, is the mecca for a majority of tourists who visit the Centennial State. The railways offer phenomenal scenic features and easy access to mining centers. Not the least of the attractions are the imposing slopes and snow cap of Pike's Peak, which seems to rise as a barrier to the principal thoroughfares, an impressive mountain, first brought into public notice a century ago, by the report of Lieutenant Zebulon W. Pike, whose name the peak bears, and made famous as an objective point for pioneers and emigrants wearily tramping the seemingly endless plains, in search of precious minerals, or a home in the then unknown "far west," whose slogan was "Pike's Peak or bust."

Florence, with its oil wells producing a thousand barrels daily, its metallurgical works, and the marvelous fruit belt tributary to Florence and its neighbour Canon City, Portland, with its central industry, the rich mineral development of Cripple Creek and Victor, and the coal fields along the Frontal Range, all contribute evidence of progress in the Pike's Peak region.

The vistas obtained from the summit of Pike's Peak, 14,147 feet above sea level, seem unlimited. To the east lie the great plains, seemingly as level as a floor, although there is much rolling ground, at an approximate altitude of 5000 feet, the region of extensive fruit, melon, and beet sugar cultivation, supported by extensive systems of irrigation. Other views give successions of snow-clad mountain ranges, all of which have been prospected for mineral, and encouraged developments, such as Leadville, which has produced $250,000,000 in gold, silver, manganese and iron, and the newer Cripple-Creek-Victor settlement, whose mines are contributing $2,000,000 in gold monthly, and supporting nearly 20,000 people, at elevations ranging from 9000 to 10,000 feet above sea level.

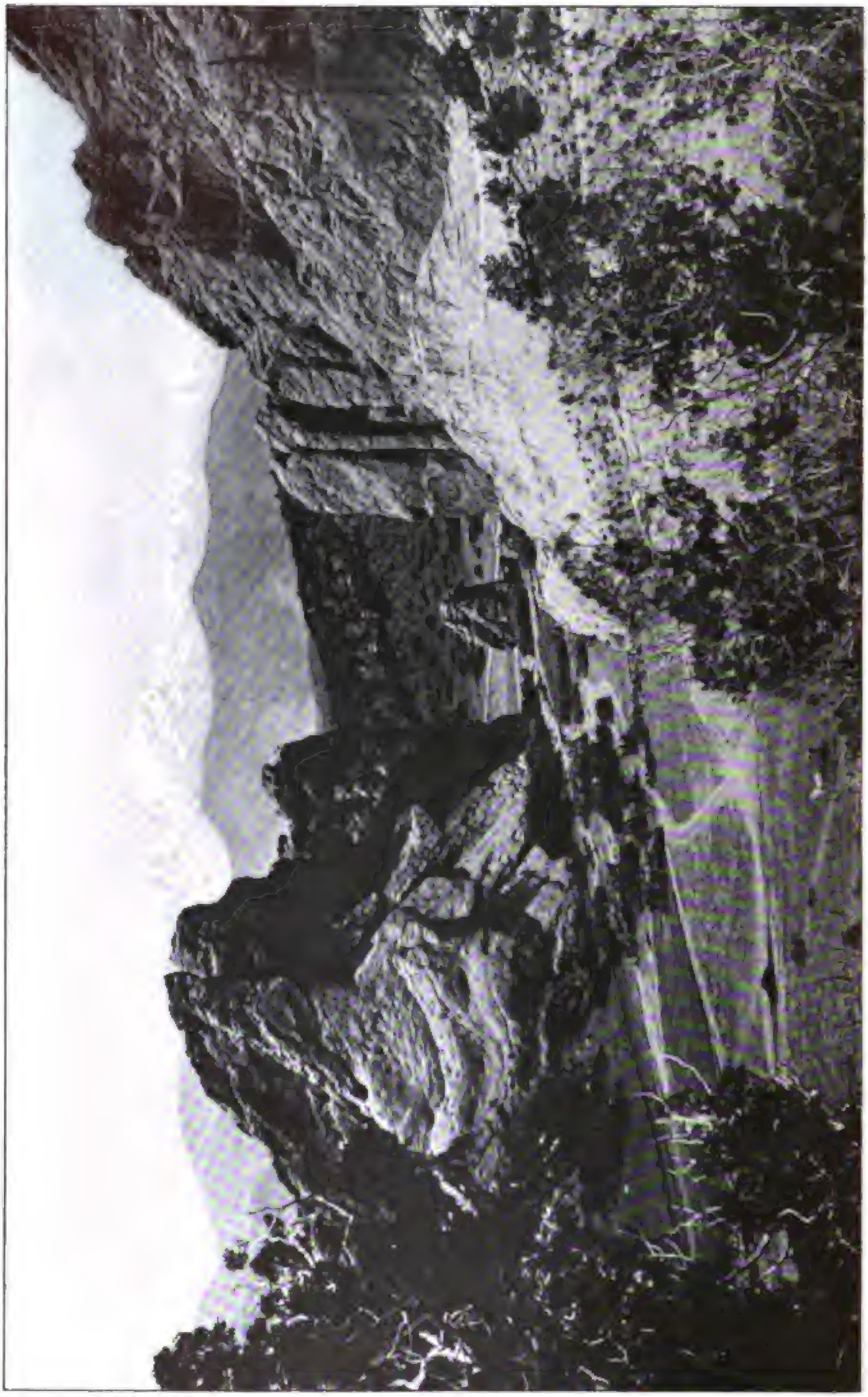
In every gulch or canon, on abrupt slopes of the mountains and far above timber line, are the dump piles of the miners' prospecting shafts and dogholes, many being records of blasted hopes, yet indicative of determination and persistent effort. Standing on this summit, with no sound of the busy world below reaching us, and looking east over the boundless stretch of prairie, Manitou and Colorado Springs appear below as children's toy villages, railroad tracks are as mere pencil marks on a print, and industries at Pueblo, or mines at Cripple Creek are located by columns of smoke; then, viewing the apparently unending mountain peaks, at elevations of from 9000 to 14,000 feet, one feels what small factors of the great world we individually are.

Lieutenant Pike started from St. Louis on July 15, 1806, on his trip to the Rocky Mountains, or Mexican Mountains, as he called them, and reported the country through which he traveled so devoid of sustenance for human beings that it would for all time serve as a barrier in the expansion of the United States. "The wide plains that staggered his imagination on account of their desolation are now dotted with prosperous farms or ranches. The mountains that appealed to him only with their scenic grandeur have been found to be the treasure vaults of nature, then waiting to be opened by the hardy frontiersmen who followed Pike nearly half a century later." The great white mountain that he declared could not be ascended by a human being, is now the objective point of thousands of tourists annually.

Lieutenant Pike was, when twenty-seven years old, chosen to lead the important military expedition on which he discovered the peak. He had previously traced the head-waters of the Mississippi to their source, and this second journey was through the

LIEUT. ZEBULON W. PIKE, WHO DISCOVERED THE PEAK IN 1806

then unexplored territory of Louisiana. He was in command of a squad of private soldiers, a physician, guides, Indians and horses. The condition of the little party was becoming desperate when, on November 15, 1806, the "Mexican Mountains" were sighted from the banks of the Arkansas River in what is now Western Kansas. Pike determined to press on to the "great white peak." On November 27, 1806, when he and two followers climbed to the top of a mountain some 15 miles from the peak, Pike wrote in his diary that the great white mountain seemed to be



GATEWAY TO THE GARDEN OF THE GODS.—PIKE'S PEAK

as high again as the mountain he had climbed, and that it would be impossible for a human being to reach the summit.

After noting the peak, Pike returned to the Arkansas River at a point where Pueblo now is, continuing his journey into the mountains and thence to New Mexico, where he was captured by the Spaniards.

But the purpose of this contribution is to invite attention to some special problems which have been, or are to be solved by engineers in the vicinity of Pike's Peak, and not to discuss Pike's expedition to this corner of the Louisiana purchase, for using the summit of Pike's Peak as a center, a radius of 50 miles will include many industrial and engineering features of phenomenal interest and bold conception.

A century seems a longer interval of time in the newer settled portions of the country than on the eastern sea-board, but even there, buildings 100 years old are so unusual as to attract notice. There is, however, nothing to-day in the vicinity of Pike's Peak which existed when General, then Lieutenant Pike, first visited that locality, except the eternal hills, a few trees, remnants of the forests, and ancient Indian trails, some of which have been developed into roads; in fact there are few buildings extant which Fremont saw in 1843.

Half a century ago the settlements were few and widely separated, but to-day important municipalities, such as Denver, Pueblo, Colorado Springs, Victor, Cripple Creek, Florence, Canon City, Trinidad, Salida, Leadville, etc., are well built, supplied with water, gas, electricity, trolley systems, and other public utilities, while the valleys and plains support innumerable farms and extensive fruit orchards.

The engineer has encircled Pike's Peak with railroads, and on the summit are seen the smoke and steam from the locomotive which has climbed the mountain by the cog road. He has pierced adjacent hills with shafts, drifts, and tunnels, harnessed water-powers, constructed reservoirs and ditches, built metallurgical and other industrial plants, laid out cities, with water, gas, sewer, and electric light systems, constructed trolley roads, etc.

The trains, seen from the summit of the peak, travel on rails made in Colorado; the motive power is developed by coal mined within the State, some of the coal workings being plainly in sight; and the smoke from smelters, reduction works, steel plants, and cement works indicate industrial activity in the vicinity of Pike's Peak. From the United States station on the summit, weather reports and meteorological observations are daily telegraphed, and visitors can communicate with friends in any part of the world.

Some of the roads in the vicinity of Pike's Peak evidence boldness in conception and perfection of construction, giving excellent opportunity to exhibit the skill of the whip, or chauffeur and for the enjoyment of those who travel on wheels or on horseback.

THE RAILROADS

In railroad construction marked ability has been shown, and passengers in turn are charmed by the impressive near views of cliff and canon, the vistas of great plains and extensive mountain ranges, or startled by the succession of deep cuts, high embankments, bridges, tunnels, sharp curves, etc.

Railroad history in the Pike's Peak region dates from 1870, when the Denver & Rio Grande Railway constructed its line from Denver through Colorado Springs to Pueblo, and subsequently from there west and south. The western extension includes the location of the roadbed beside the Arkansas River, through the cleft in the hills, which, in the "Royal Gorge" shows a vertical depth of over 2000 feet, to Salida, from which point branches pass over the Conti-

nental Divide, via Marshall and Tennessee passes, and into the Rio Grande basin over Poncha Pass. Later, the Atchison, Topeka & Santa Fe Railway paralleled the Denver & Rio Grande, climbing the summit at Palmer Lake, at 7237 feet altitude, to Colorado Springs, Pueblo, and La Junta, to connect with its main line to the west.

The Colorado & Southern Railway also constructed a third line, but abandoned much of it and now use the Santa Fe tracks, and the Missouri Pacific Railroad extended its road to Pueblo, to connect with the Rio Grande system. The Chicago, Rock Island & Pacific Railroad also runs its tracks into Colorado Springs and into Denver over the Union Pacific Railroad tracks. In addition two railroads start from Colorado Springs, one, the Colorado Midland, which passes through Manitou, and then, by tunnels, sharp curves up to 16 degrees, and grades reaching 4 per cent., ascends Ute Pass, encircling the north side of Pike's Peak on the South Platte drainage, thence going back to the Arkansas Valley, which it crosses, passing the crest of the continent through the Busk tunnel of Hagerman Pass, altitude 10,944 feet, to Aspen, Glenwood Springs, and Grand Junction. This road has a spur to the Victor, Cripple Creek district.

Another, the Colorado Springs-Cripple Creek District Railroad is a later connection between Colorado Springs and the mining district. It climbs the side of the Cheyenne Mountain, crossing, instead of traversing, the canons, and passes to the south of Pike's Peak. On this road curves and tunnels abound, but the gradient does not exceed 4 per cent., nor do the curves exceed 16 degrees. This road operates the high and low-line trolley systems of Cripple Creek District.

The Cripple Creek region is also reached from the Arkansas River from Florence, by a narrow-gauge branch of the Denver & Rio Grande Railroad,—the Florence and Cripple Creek branch, following a gulch or canon. The railways which encircle Pike's Peak represent two essentially distinct types of construction, two practically following water courses, and gaining height by development when the canon's declivity was too great, the other skirting the mountain side with a succession of grades and curves.

The unique feature in railroad construction in the Pike's Peak district, however, is the Manitou & Pike's Peak Railway, familiarly recognized as the "cog-wheel route," which ascends the mountain from the mouth of Engleman's Glen in Manitou, elevation 6650 feet above sea level, to the summit of the peak, 14,147 feet above the sea. This elevation of 7500 feet is overcome in a distance of less than 9 miles, the road being standard gauge with a double steel rack placed in the center of the track, the teeth meshing into wheels on the locomotive.

The road is mainly for passenger travel, and as it is claimed to be the longest in existence and to reach a higher elevation than any other, the ascent of Pike's Peak by rail has become a feature of tourist travel. In operating the road, the locomotive pushes the car up the slope and descends before it, but the two are not coupled, thus adding a factor of safety in case of derailment, the cars having individual brakes which act upon wheels meshing into the rack.

The average grade of the road approximates 16 per cent., but a maximum of 25 per cent. exists for a considerable distance, and the maximum curvature is 16 degrees. The locomotives weigh about 30 tons each and are of the compound Vauclain type of Baldwin make. The portion of the year in which this road is in service is limited by climatic conditions, but to make the summit accessible, even during the months of active travel, the snow plow, flanger, and rotary must be kept ready for service, and be used a considerable

A DISTANT VIEW OF THE PIKE'S PEAK COMPANY'S POWER HOUSE. THIS VIEW WELL ILLUSTRATES THE CHARACTER OF THE COUNTRY TRAVERSED BY THE PIPE LINES LEADING TO THE SEVERAL POWER STATIONS

time both after and also before these features of railway equipment are used on most of the Western railroads.

In a resumé of the railroad construction in the Pike's Peak region, interesting details of methods of surveying, selection of route, features of grade, curvature, rock cut or tunnel work, embankment, trestle or bridge construction are necessarily omitted, but from the brief statement presented it will be evident that the engineer has solved difficult problems, some of them in a heroic manner, to make accessible the wealth and scenic beauties in the vicinity of Pike's Peak.

This is true not only for the roads in the vicinity of the mountain, but also for those throughout the Rocky Mountain region, as there are many instances where the steel rails traverse deep gulches, span canons, or are laid in notches excavated from the sides of high cliffs, around abrupt promontories, or passing through them in curved and tangent tunnels, some of them of considerable length.

ALONG THE 30-INCH REDWOOD STAVE PIPE LINE OF THE PUEBLO & SUBURBAN TRACTION & LIGHTING COMPANY. SEE PAGE 499

THE POWER HOUSE OF THE PIKE'S PEAK POWER COMPANY

THE ARKANSAS RIVER

The Arkansas River presents interesting and varied features in its course from the Continental Divide at Tennessee, Hagerman, Alpine and Marshall passes, to its confluence with the Mississippi River in Arkansas. The blankets of snow which perennially cover Mounts Massive, Marshall, Herbert, and the collegiate ranges and Sangre de Cristo ranges, form the genesis of the Arkansas River, and the engineer has attempted to equalize some of the run-off by constructing storage reservoirs near the head-waters, and also other reservoirs, 200 miles down the stream on the great plains, their function being to feed hundreds of miles of irrigating ditches which make fruitful large areas of land. The river has an average fall of 1 per cent. in the first 100 miles, when it dashes through the canon of the Royal Gorge, with nearly vertical walls half a mile high.

In addition to liberal utilization for agriculture, enough of the water tributary to the Arkansas River is employed in placer workings to convert the pellucid stream into a muddy river, carrying large quantities of solid matter in suspension, but no serious effort has been made to adapt the volume of flow to producing power.

Most of the minor tributaries of the Arkansas River have reservoirs to store water, and ditch lines to distribute this essential for agricultural and domestic uses.

The snow cap of Pike's Peak is the source of a number of streams, the drainage being mainly to the Arkansas River through Fountain and Beaver creeks. Fountain Creek, which passes through the city of Colorado Springs, does not offer water of a character desirable for household use, but is applied to the irrigating ditches which give life to most of

PART OF A PIPE LINE SUSPENDED OVER ROUGH GROUND. IN THE BACK GROUND A WOODEN-STAVE STAND-PIPE IS SHOWN. SEE PAGE 499

the vegetation in the city and vicinity. It was a branch of this stream, about 30 miles south from Colorado Springs, which engulfed a train on the Denver & Rio Grande Railway in September, 1904, although ordinarily no water is seen in this tributary, and an 18-foot opening is considered ample provision for ordinary freshet conditions. The so-called "cloud-bursts," which occur at irregular intervals along the frontal mountain range, usually prevail over limited areas, but on these the precipitation is enormous. In railroad construction it would therefore become neces-

sary to provide at each arroya crossing for an area of waterway which appears out of all proportion to the normally dry, or nearly dry, stream beds which are crossed by tracks. Unfortunately, few of these "cloudbursts" have occurred where rain gauges were established, or where exact data are obtainable, and the relation of volume of flow and of drainage area is undetermined.

An interesting development in progress between Colorado Springs and Pueblo is the attempt to collect from the underground waters in the Fountain Creek Valley a supply for the city of Pueblo. Clay drain pipes laid across this valley are expected to collect the subterranean flow and divert it into a concrete conduit line 36 inches in diameter, which will connect with a wooden-stave pipe line of the same diameter, for furnishing water by gravity to the busy city of Pueblo.

The presence of subterranean waters in pervious gravelly strata below the sand, and adobe surface cover of the plain slopes, has been the subject of a monograph published by the United States Geological Survey, and enters as an important feature in the litigation by which the State of Kansas seeks to limit the application of the water of the Arkansas River in Colorado to irrigation.

SOME WATER PROBLEMS

Few visitors who enjoy the well-shaded streets and clear water of Colorado Springs are aware that the water supply for this city of 30,000 inhabitants is unique in some features, and an exhibition of commendable public spirit which encouraged the liberal financial outlay, approximating $3,000,000, which the system demanded. Nor do tourists realize that every tree which borders the streets was planted, every building in the city erected, within the past thirty-five years.

Far up the southwesterly slopes of Pike's Peak, close to the perennial snow cap, and partly above timber line, are a series of lakes or ponds, some natural and some artificial, from which Colorado Springs, Victor, and Cripple Creek obtain their water supply. The contest for water has been carried on, even at these elevations, with such persistency that armed guards have at times been stationed to prevent pilfering the precious liquid. Others, claiming to be lawful owners, have invoked the law and submitted guards to imprisonment, and turned the waters into the claimed rightful channels, while prolonged legal battles have been fought to maintain or protect water-rights.

With a rainfall approximating 15 inches per annum, a considerable portion of which falls as snow and remains upon mountain ranges, and with part of the balance deposited in severe storms, more or less local, the conservation and utilization of water is a question of serious moment, and Colorado was the pioneer in making legislative provisions for the control of its water supplies. By the laws now operative the Governor appoints a State engineer, and irrigation division engineers for each of such prominent drainage basins as those of the Platte River, the Arkansas River, the Rio Grande River, and others. In addition about sixty water commissioners are appointed by the Governor, each of these being in charge of a defined water district. The State engineer has absolute supervision of all water resources of the State of Colorado and their utilization. Through his deputies he measures the allotment of all water-rights and passes upon the construction of all dams or reservoirs.

Early in the settlement of the Rocky Mountain section, the necessity of artificial irrigation became apparent, and owing to the depleted condition of the streams during most of the year, the right to take water to irrigate a specific section was acknowledged, and was at first a part of the deeds. As the number of settlers increased and the demands for water became greater, applications

exceeded the normal capacity of most of the streams, and water-rights have been granted for greater volumes than pass down their channels, even in time of ordinary freshets, or when the rapidly melting snows from the mountains send down water in great quantities.

Colorado early established the right of priority; that is, the parties who made application for and were granted water, have prior claims than others whose applications are filed and allotments made at later dates, and these water-rights have become a matter of purchase and sale, their values being based largely upon the date of appropriation.

The adjudication of water-rights is, therefore, in many cases quite difficult, and efforts to settle conflicting claims by resort to force were to be expected in cases of emergency which arose before the disputes could be heard by the State officials. Such rival claims for certain water from Beaver Creek led to contentions between Colorado Springs and Cripple Creek.

An outline of the principal supply for Colorado Springs will illustrate some of the difficulties which have been overcome by the municipality and its engineers in obtaining an adequate supply of desirable water. Beaver Creek drains a large portion of the south and west slopes of Pike's Peak, and on one of its tributaries a reservoir was constructed at an elevation of 12,100 feet above sea level. From this the water is led to a second reservoir on another tributary at an elevation of 11,700 feet. From this second reservoir the water is conveyed by a tunnel 6500 feet long into another water-shed, and to a third reservoir at an elevation of 11,280 feet. This tunnel, 5 x 7 feet, has an average grade of 0.5 per cent. in addition to a drop of 6 feet, reported to be due to errors in level when the headings from the two entries met. A second tunnel, half a mile long, conveys water from another stream. After following an open channel for a mile, the water enters a steel pipe, 18 inches in diameter, which leads to a hydro-electric power station operated by the Cripple Creek Short Line Railway Company.

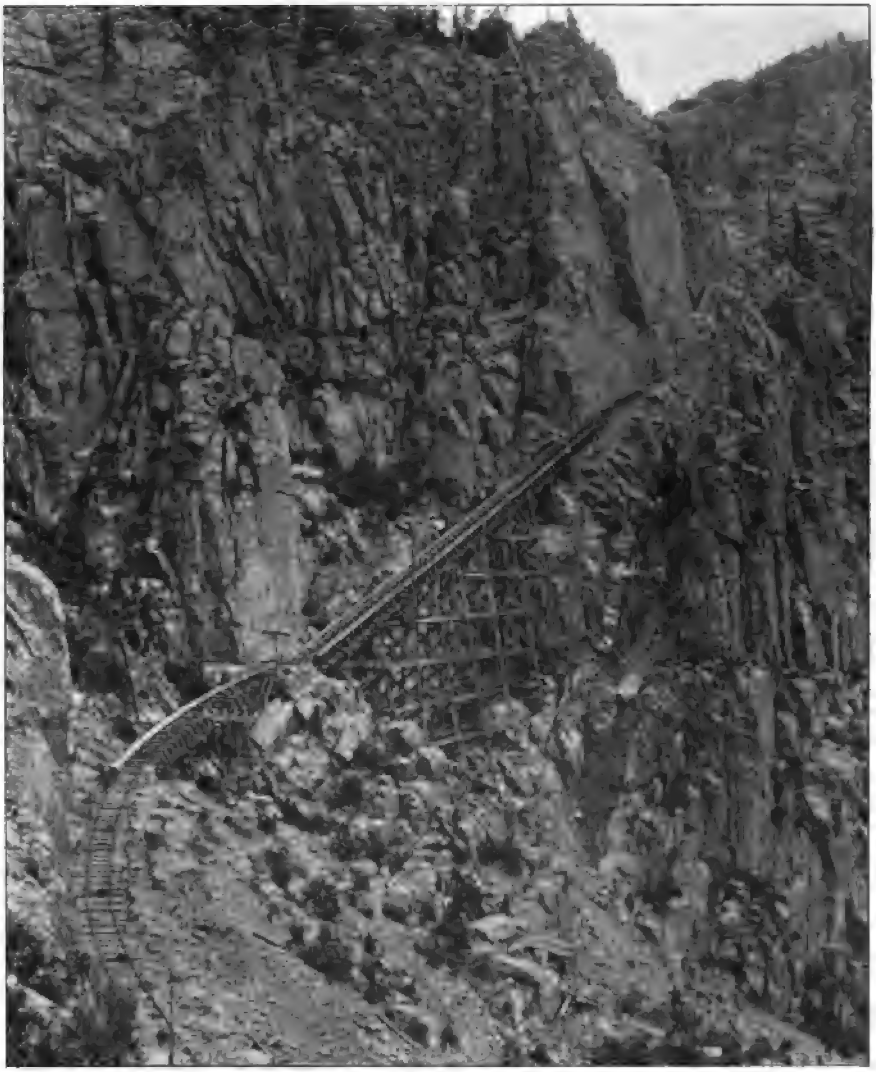
The plant has a Pelton waterwheel under 704 feet head, driving a 300-KW., three-phase, alternating-current generator, yielding current at 6000 volts and 60 cycles per second. The current is transmitted to the Cameron power house of the Colorado Springs & Cripple Creek Railway, distant 12 miles, and is there transformed by two 150-KW., rotary transformers into direct current at 550 volts, and the direct current, working in parallel with that of the steam-engine driven generators at that power house, supplies current to the electric railways between Victor and Cripple Creek.

From the hydro-electric plant the water passes into Lake Morrain, a reservoir with a capacity of 492,000,000 gallons, at an elevation of 10,246 feet, constructed by connecting portions of a natural morrain by an artificial embankment.

From Lake Morrain a natural channel is followed for 1¾ miles to a second metal pipe-line, 19 to 21 inches in diameter, which has moderate grade for 8000 feet, and then plunges down the steep mountain side for 6000 feet, measured on the slope, having in this total distance a fall of 2417 feet, to the Manitou power station of the Pike's Peak Hydro-Electric Company, located close to the foot of the cog railroad leading to the summit of Pike's Peak.

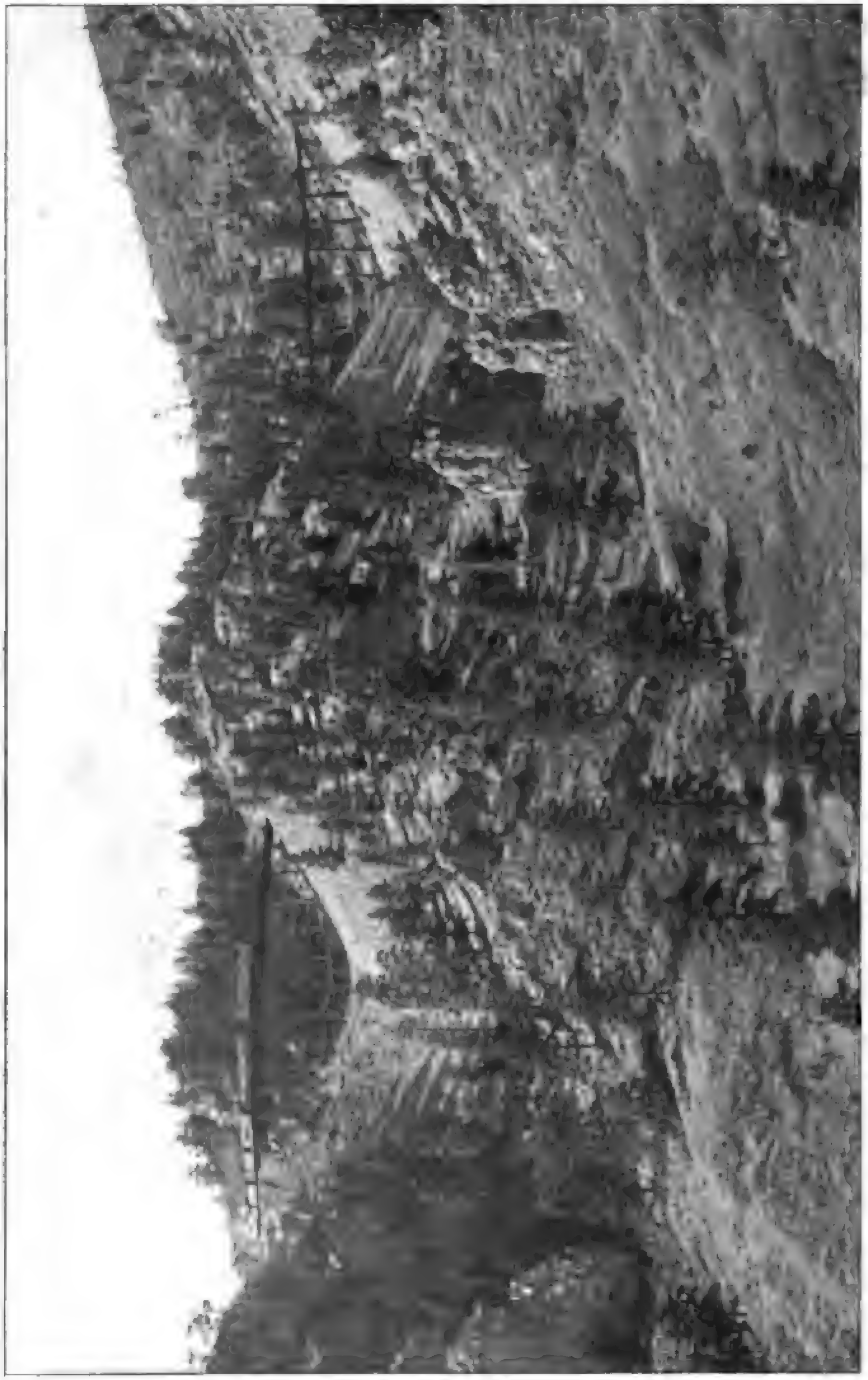
The pipe on the steep slope is of riveted steel, 19 inches inside diameter, the lower sections being under a static pressure of 1047 pounds, and when in operation under 940 pounds. This pipe, formed in sections 32 feet long for transportation on railway cars, was handled to place on the steep mountain faces by a tramway, the power for moving the tram cars being a cable operated by electricity.

This power station of the Pike's Peak Hydro-Electric Company is in-



THE LOWER PART OF THE PIPE LINE OF THE PIKE'S PEAK POWER COMPANY IS OF STEEL AND IS CARRIED ON AN INCLINED TRESTLE AND AROUND A SHARP CURVE

teresting because of the phenomenal head under which it operates,—2417 feet,—and because of the equipment, which consists of three Pelton water-wheels, each directly connected to General Electric Company generators, rated at 750 KW. at 6600 volts and 66 amperes, making 450 revolutions per minute. The wheels are 7 feet 4 inches in diameter at the pitch line of the buckets, or 7 feet 9 inches over all. Each consists of a steel disk, 1½ inches thick, to which are secured 36 bronze buckets, revolving when in operation at a circumferential speed of 11,000 feet, or 2.08 miles per minute. Water is applied to each wheel through a 2¼-inch nozzle, the volume being controlled by a needle valve and the speed by Lombard governors which deflect the nozzles. There are also two excit-



TWIN BRIDGES ON THE CRIPPLE CREEK SHORT LINE. THE 3½ PER CENT. GRADE OF THE ROAD IS INDICATED BY THE DIFFERENT ELEVATIONS OF THE TWO BRIDGES

ers operated by small water-wheels.

Taking the plant at its rated capacity, it is doubtful if any other locality in the United States can show over 3000 horse-power generated by water in such limited space. It is also doubtful if any plant elsewhere operates under as high hydraulic pressure, except at Vourvrey, Switzerland, where 3030 feet are the head reported as used for an 8000-H. P. hydro-electric plant. The project of utilizing the fall in the Colorado Springs water supply includes a second power plant to be installed in the future above that described, which will operate under 1200 feet head.

In this outline the water has been traced for a distance of 7 miles, falling 5500 feet, of which fall 3121 feet are now utilized; but en route the water is augmented by connection with minor tributaries.

After developing power at the above mentioned station, the water passes to a tank, at an elevation of 6633 feet, which feeds the present 18-inch and 10-inch pipe-lines, 6 miles long, connecting with the distributing system of Colorado Springs, at an average elevation of 6200 feet, the surplus discharging into the city distributing reservoir at 6400 feet elevation.

The two hydro-electric plants mentioned are not operated by the city of Colorado Springs, which cannot enter into the commercial field, but the water is supplied to independent companies. The plant last described furnishes electric light and power to the city of Colorado Springs under charter privileges.

The problem of operating a power station in connection with a city water supply is full of complications, because in the season of large water requirements the demands upon the power plant are less severe than in the winter months, when less water is used in the city. The same holds good for the variations of load at different hours of the day, but the distributing reservoirs can care for this. As waste of water cannot be permitted, it is evident that an adjustment of conflicting interests is essential, and that the best result demands a partial dependence upon the steam auxiliary plant in Colorado Springs.

Another impressive installation is the hydro-electric plant of the Pueblo & Suburban Traction & Lighting Company, on West Beaver Creek, on the slope of Pike's Peak. Five and a half miles east of Victor a steel-faced, rock-filled dam was constructed, forming a reservoir with a capacity of nearly 200,000,000 cubic feet, with the water surface about 9100 feet above sea level, the drainage area above the reservoir dam being 70 square miles. The dam closes an opening in the granite rock 220 feet wide at the base and 450 feet wide at the crest of the dam; the height from bed-rock to the dam crest is 90 feet. The inner slope (steel faced) is inclined 30 degrees and the outer slope 50 degrees from the vertical; the crest is 20 feet thick and the spillway is 60 feet wide.

Water is drawn from this reservoir by means of wooden-stave pipe, 30 inches in diameter, the staves being secured by steel bands spaced from 2¼ to 8-inch centers, according to the head, which in passing depressions reaches 215 feet. This pipe-line, 21,000 feet in length, is constructed through extremely rough country, some of the curves being of less than 100 feet radius, and one compound curve is stated to have a radius of 35 feet. The pipe passes through a tunnel over 1500 feet long, and a portion of it is suspended by cable. See page 494.

In addition to the wooden-stave pipe, 2900 feet of riveted steel pipe, 29 inches in diameter, have been laid, commencing where the static head is 120 feet, and continuing to the power house where the static head is 1165 feet. The shell of the steel pipe section ranges from ¼ to ¾ inch in thickness, and the pipe is laid on grades varying from 12½ to 57 per cent. At one place this pipe is laid on a bridge

74 feet high and through a tunnel, both of which are on a 40 per cent. gradient.

Water is conveyed from the reservoir through the pipe-line mentioned to four hydro-electric units operating under 1150 feet head, each unit consisting of two Pelton water-wheels, 66 inches in diameter, directly connected to 400-KW. generators. There are also two 30-KW. exciters. Current is transmitted to Victor, 8 miles, and is there transformed to 12,000 volts, part of the power being used at several mines in the Cripple Creek district and the balance carried to Pueblo, 30 miles distant, to operate the city trolley system. Plans for developing additional powers at points further down Beaver Creek have also been prepared.

The portion of the great plain within the range of vision from the summit of Pike's Peak is liberally supplied with irrigation canals, ditches. and reservoirs of great size. Colorado is credited with over 12,000 miles of irrigating canals, which make productive about one million acres of land, and some of the larger enterprises supply portions of the territory embraced in the Pike's Peak region.

One instance which illustrates the magnitude of the irrigating projects, is the enterprise of the Twin Lakes Land & Water Company, to which have been appropriated 750 second-feet from the flow of the Arkansas River. To supplement the normal stream delivery, the company raised the level of Twin Lakes,—two adjacent natural bodies of water in the Rocky Mountains, at an elevation approximating 9200 feet above tide.

Water stored in this combined reservoir, with an area of 2500 acres, is let into the Arkansas River as required, and flows in the stream bed for 160 miles to the head-gates of the company's large canal, which is 40 feet wide at the bottom and 6 feet deep, meandering on the land contours for many miles, and feeding numerous smaller ditches for watering the great area controlled, and several large reservoirs en route.

Under the laws of Colorado water can be stored during the flood season, or at any time when excess water is not needed for direct irrigation, and thereafter turned into the river in times of scarcity; and the same quantity as is let out of the reservoir (with a percentage deducted for seepage and evaporation while in transit in the river) may be taken out of the stream by the irrigation canal entitled to it. At present four days are calculated as the time of travel of the water in covering the 160 miles between Twin Lakes reservoir and the company's head-gates on the Arkansas River, and pending more exact determniation a discount in volume of 10 per cent. is estimated.

To provide ample water supply for its Minnequa steel plant at Pueblo, which turns out 1500 tons of manufactured product a day, and to meet an increased output, the Colorado Fuel & Iron Company have constructed a comprehensive water supply which should deliver to it continuously 50,000,000 gallons of water per day by gravity. The company controls the right to divert 80 second-feet of water from the Arkansas River, and to maintain this a storage reservoir has been constructed on the Lake Fork of the Arkansas River, which the Colorado & Midland Railway follows in reaching Hageman Pass. The function of this reservoir with a storage capacity of 5,640,000,000 gallons is to store the excess water resulting from melting snows, and, under the direction of the State engineer, turn it into the Arkansas River when needed to make up deficiencies.

The water surface of this reservoir covers 820 acres, and is at an elevation of over 10,000 feet above sea level. In maintaining the flow, the water will be discharged from the lake into the Arkansas River, being subject, in following its bed for 130 miles, to discount and time allowance as stated for the Twin Lakes, and is carried to

the head-gates of the ditch line. From these head-gates a conduit has been constructed, 38 miles in length, of which 12 miles consist of wooden-stave pipe, ranging from 54 to 60 inches in diameter, laid in the river bottom within a few miles of the head-gates, and crossing "arroyas," which are deep gashes formed in the plains by water courses. Some of these siphon crossings are short, others approximate a mile in length, the depth varying, but increasing as the conduit approaches the plains reservoirs. The maximum head upon any siphon is 150 feet.

A considerable portion of the conduit is a ditch excavated in the rolling prairie or plains, but much of the work is difficult engineering, such as ditches cut on the faces of cliffs, some of which overhang, or driven through disturbed strata or loose material, where a concrete lining is necessary. On the route there are 25 siphons and 5 tunnels. The lower end of the ditch discharges into a reservoir system established on the plains over 4 miles from the Minnequa steel plant, with which it is connected by a line of 28-inch wooden-stave pipe, and an additional line, 48 inches in diameter, of the same construction, is now being laid. The upper reservoir holds about 1,000,000,000 gallons, and the lower one, 500,000,000 gallons, this latter giving a head on the works of 150 feet. There is also a supplementary reservoir at a lower elevation, with a capacity of 500,000,000 gallons.

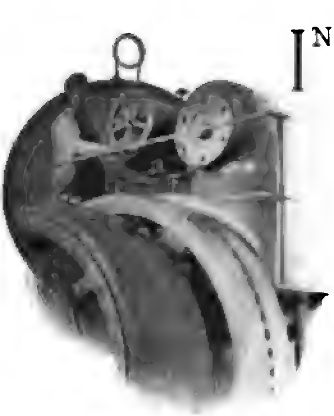
While this installation is expensive in first cost, the fact that no pumping will be required is to its advantage, and it is probable that the interest and sinking fund charges plus the necessary operating expenses will compare favourably with the pumping expense at other steel works where a similar amount of water is mechanically elevated.

The foregoing statement is merely suggestive of the many problems in engineering which have been met in the Pike's Peak region. They demonstrate the progressive and bold spirit which has overcome so many difficulties in the commercial development of territory, which, a half-century ago, was believed to be uninhabitable and a barrier to human progress. It is in surmounting difficulties that man makes his best achievements, and few localities are more prolific in evidence of this than the Pike's Peak region.

RECIPROCATING STEAM ENGINES vs. STEAM TURBINES

A COMPARISON OF OPERATION BETWEEN TWO POWER HOUSES OF MODERN TYPE

By W. P. Hancock



IN an attempt to say anything referring to comparsons between engine and steam turbine stations, it seems reasonable to assume that statements based on records made from practical experience and the commercial use of both of the above types of steam apparatus will be more valuable and more interesting at this time than theoretical deductions, which, while absolutely necessary in the designing of the apparatus, and also in making necessary changes, in order to obtain a test performance from the unit as nearly correct as possible, are not by any means conclusive.

An athlete, or a race-horse, about to compete for honours, is fitted to the minute, with a view to have them make the supreme effort of their lives, and they perform, we will say, satisfactorily, but what then occurs? A long rest is given, and various things are considered, in order that the man, or the horse, may, within a reasonable period, again successfully compete. Therefore, we may test a new unit, of a new type, and it may show a performance which complies with the builder's guarantee, and if it does, that practically absolves the builder; but the buyer of the unit will be thoroughly satisfied only when he can see by consulting his cost sheets that in a full year of operation the new unit has proved beyond question that it is less expensive to operate, and, to a degree, that it will be profitable for the user to further install and operate that type of unit. In other words, what is most valuable and interesting to know is the result of a continuous, instead of a test, performance of the new unit.

I shall, therefore, speak of a power house operated by reciprocating engines of one of the best types, and a power house operated by steam turbines of a new type now very prominent in the market. Both of these power houses are situated on the water front. Both use the same grade of coal, costing approximately the same per ton. The circulating water for both comes from the same source, as does the boiler feed water, the latter being taken from city water service. Both power houses are operated by one set of men, and the loading of the stations is conducted with a view to obtaining the lowest cost per kiliwatt-hour consistent with good and continuous service.

I shall speak of the performance of these power houses, as shown for the calendar year 1904 for the engine station, and the calendar year 1905 for the turbine station; and I have chosen these years for the reason that in each case each station in those periods had a load factor that enabled it to show a satisfactory performance, if its capabilities had been

TABLE I.—EQUIPMENT OF THE TWO POWER HOUSES.

	Engine Station.	Turbine Station.
Units	6—1600 K.W. cycles 60.	2—5000 K.W. cycles 60.
Boilers, water tube	12—550 H.P. No superheaters.	16—512 H.P. Superheaters.
Furnaces	Hand-fired.	Mechanical stokers.
Auxiliaries	Principally steam. Modern types.	Principally steam. Modern types.
Builder's rating (total)	9000 K.W.	10,000 K.W.

correctly estimated; and I will add, there is no doubt today about that part of the matter, in either case.

Table I. gives approximately the equipment of each power house and, later, a division of the labour as charged to the pay roll will be given.

The furnaces in the engine station are hand-fired and not economical if we refer to labour, but very much so if we refer to evaporation, fast steaming qualities and repairs. The turbine station furnaces have mechanical stokers, and, naturally, the labour expense with them is much less.

The fuel used is "New River" bituminous coal, and an analysis and the method of making analyses follow:—Three samples of coal were taken each day. The samples taken on Wednesday, Thursday and Friday were combined, and one analysis was made from them.

The samples taken on Saturday, Sunday, Monday and Tuesday were combined and an analysis was made from them, or two analyses per week from the combined samples.

	1904.	1905.
Moisture in sample, per cent	4.24	4.24
B. T. U. per lb. dry coal	14,834	14,715
Organic and volatile, per cent	24.12	24.98
Fixed carbon, per cent	70.96	69.81
Ash, per cent	4.92	5.21

After looking over the analyses for both years, it seems plain that the fuels were nearly alike in quality. This is one of the greatest factors necessary to make a consistent comparison. The cost of the coal per short ton in 1905 was about 2 per cent. less than the cost in 1904, and, therefore, that particular point would tend to favour the operation of the turbine station on total cost, but we notice also that the B. T. U. in the 1905 coal were less than in the 1904 coal, and also that the ash was greater to a small degree, and these conditions therefore again tend toward a fair comparison.

The other conditions of operation were as given in Table II.

The boiler feed water for both power houses costs alike per thousand cubic feet, and, as I have said, is taken from the same source.

I will also say that all of the labour is classified and paid a standard wage under the classification, all of which tends toward making the comparison a fair one, that is to say, no advantage accrues to lessen the cost of operation of one station over the other by a discrimination in the hiring of men, at a price which would benefit one station over the other.

Then, to start with the labour in the engine station boiler room which has hand-fired furnaces, we find that with a peak load in December of 10,175 K. W., we operated ten 550-H. P. boilers with a maximum of twenty-five men for twenty-four hours, including a fire room engineer. The average number of men employed in the boiler room for the total year was twenty-three.

The total coal consumed was 44,813 short tons, and the average number of tons handled per day of twenty-four hours was 123. The number of firemen employed was fifteen, and the water-tenders did some firing also. The average amount of coal handled by each man (floor to furnace) was, per day of eight hours, 6.8 short tons. The refuse from fires, ash pits and boilers, for the year, was 3,736 tons, all of which was

TABLE II.

	Engine Station, 1904.	Turbine Station, 1905.
Output, kilowatt-hours	37,912,000	33,840,800
Load factor $\left\{\frac{\text{Average}}{\text{Av. max.}}\right\}$	0.588%	0.645
Short tons coal consumed	44,813	44,364
Pounds coal per kilowatt-hour	2.36	2.62
B. T. U. per lb. dry coal	14,834	14,715
Steam pressure	160	175
Feed water temperature, Fah.°	183	149
Vacuum (inches mercury)	26	28.5
Superheat, degrees	None	150

taken from the floor of the boiler room to the yard by the coal passers, that work being a part of their duties, additional to passing coal and cleaning.

It should also be borne in mind that all of these men did not work all of the time, as under existing rules all of the men employed on the system seven days per week are entitled to and do receive fourteen days off in the course of the year, without loss of salary, and this amount of time may be taken as a man may desire, subject to the approval of the chief engineer, for either vacation or sick leave, and between April 1 and September 1.

The total fire room force was divided as follows in the engine-operated station:—

Fire room engineers	1	Average number of men for each type of work for the year 1904.
Water tenders	3	
Firemen	15	
Coal passers	3	
Cleaners	1	
Total	23	

Relative to the disposal of ashes, I will say that this item is one which incurs expense, as the total output of ashes from both power houses has to be hauled away by contract; but this has no weight in making a comparison, and I mention the matter only in connection with the fact that some companies receive a benefit from the sale of ashes, which has shown a credit to operating expenses of 1 per cent.

Having covered the engine station boiler room items, except in the comparison of costs, which will come later in tabulated form, we will take up the boiler room of the turbine station, where no manual labour is employed to handle coal, and mechanical stokers are in operation.

The ashes go to the pits, which have a capacity sufficient so that removal is necessary only once in twenty-four hours. Of course, this is a very different proposition for handling and burning coal as compared with the one in the engine station, as well as a most important one, for it is true that no matter where you save the cost, it all shows in the ultimate cost per kilowatt-hour manufactured.

Then to take up the labour in the turbine station boiler room, we find that with a peak load of 11,025 K. W. in November, 1905, we operated eight 512-H. P. boilers with a maximum of eleven men for the twenty-four hours, including a fire room engineer. The average number of men employed in this boiler room for the total year was eleven.

The total coal consumed for the year was 44,364 short tons, and the average number of tons handled per day of twenty-four hours was 121.2. The number of firemen employed was four. The same vacation privileges obtain as in the engine station, and for all employees in the room.

A summary of the total operating fire room labour in each station is given in Table III.

TABLE III.

	Engine Station Boiler Room.	Turbine Station Boiler Room.
Fire room engineers	1	1
Water tenders	3	3
Firemen	15	4
Coal passers	3	3
Cleaners	1	..
Total men	23	11

I may say with reference to the coal passers mentioned in the summary for the turbine station, that there is installed in that station, over each boiler, a set of Howe beam scales, so arranged that each chute of coal can be weighed and recorded before it goes to its respective feed hopper and to the fires, and it is a part of the duty of these coal passers to weigh and record the amounts of coal sent down, and, additional also, to keep the conductors from chutes to hopper clear, and, incidentally, to keep his particular territory swept and as clean as can be under business conditions.

Now to compare the labour employed in the turbine station, as compared with that of the engine station boiler room, we can refer to Table IV., and in so doing we will assume the total number of men employed in

TABLE IV.

	Fireroom Labour Engine Station.	% of each to the Total Engine Station.	Fireroom Labour Turbine Station.	% of each to Total of Engine Station.	Ratio Turbine to Engine.	Turbine Decrease over Engine.
Fireroom engineers	1	4.3	1	4.3	1.000	.0
Water tenders	3	13.1	3	13.1	1.000	.0
Firemen	15	65.2	4	17.4	0.267	73.3
Coal passers	3	13.1	3	13.1	1.000	....
Cleaners	1	4.3	0	....	....	100.0
	23 men	100.0%	11 men	47.9%	0.479%	52.%

the engine station to be represented by 100 as a standard, and that each type of labour is a percentage of that 100.

Explanatory of Table IV. we find that of the total labour employed in the engine station the fire room engineer is one-twenty-third, or 4.3 per cent; the water tenders are three-twenty-thirds, or 13.1 per cent.; firemen fifteen-twenty-thirds, or 65.2 per cent.; coal passers three-twenty-thirds, or 13.1 per cent.; cleaners one-twenty-third, or 4.3 per cent., making the total of 100 per cent.

As to the number of men employed in the turbine boiler room as compared with those in the engine boiler room, we find by still adhering to the 100 per cent. used in distributing in the case of the engine portion that the fire room engineers, water tenders and coal passers are of the same percentage of value, but that the firemen are only 17.4 per cent., or four-twenty-thirds of the total of that type of labour used in the engine portion, and that no cleaner is used in the turbine portion, as spare time is available at low-load periods to enable this work to be done by the regular force.

Then it follows that the labour of firemen is, in the turbine portion, 26.7 per cent. of what it is in the engine portion, representing a decrease of 73.3 per cent., and as all firemen receive the same wages the result is a decrease in cost between the two boiler rooms, in direct proportion to the percentage given. The same also is true of the value of the decrease of cleaner labour, as all of this type of labour receives the same wages.

We find also that the turbine boiler room force in total is eleven-twenty-thirds of that of the engine boiler room, or 47.9 per cent. (fractions of percentage may vary one or two-tenths due to additions of decimals of second place).

It appears to be plain that from the existing boiler room in question, with its hand-fired and, in part, economically operated furnaces, we have stepped forward to something of the same general utility, but also to something vastly more economical from the labour standpoint, and additional to that we do not have to employ so many men to burn a given amount of coal, and have it burned economically, as we did in the first-mentioned boiler room. There are times and conditions, as every operator and every power producer for that matter knows, when it is an easier matter to produce and place before the fires half a dozen first-class firemen, than it is to obtain four times that number. Additional to economy of labour, the above is one of the greatest of incentives for installation of a good type of mechanical stoker.

We have not, however, covered all of the ground which should be covered in the boiler room expense, for the question of repairs and renewals should be compared in a thorough manner also, and to do this I shall add to the previous table a comparison of repairs in both of the boiler rooms, and then show a total boiler room operating and repair expense in comparison.

The total repair and renewal cost in the engine station boiler room for 1904 was 2.1 per cent. of the total cost per K. W.-hour, being divided as follows:—Grates, 1.4 per cent.; boilers, 0.7 per cent. Taking the combined cost of boiler room repairs

on engine station as 100, we find it divided in proportions as follows:—

Grates, 1.4 per cent of the total cost per kilowatt-hour, and 66.7 per cent. of the total cost of boiler room repairs.

Boilers, 0.7 per cent. of the total cost per kilowatt-hour, and 33.3 per cent. of the total cost of boiler room repairs.

The cost of repairs on grates in the turbine station boiler room was 100 per cent. of the total repairs in the engine station boiler room, while the cost of boiler repairs in the turbine station was 9.5 per cent of the engine station boiler room repairs. The figures have been collected in Table V.

making no qualification as to such a statement.

As I expect that a reader of this paper may at this time wonder how the coal is handled, and where the expense of such work is charged, I will state that the fuel for these power houses is shipped by water, and that the total cost of a short ton delivered to both the power house boiler rooms includes:—

1.—The base price of the coal f.o.b. tide water.

2.—The freight.

3.—The insurance.

4.—The discharging to storage field.

5.—The handling from storage field to bunkers over boilers.

TABLE V.

	Percentage of Total Cost per K. W. H. Eng. Sta.	Proportion of 100 Engine Station.	Turb. Sta. % of each Acct. to Total Cost of Eng. Sta.	Percentage of Boiler Room Repairs Turb. Sta. to Total of Eng. Sta.	Ratio Turbine to Engine.	+=Increase. —=Decrease.
Grates..................	1.4	66.7	2.1	100.0	1.500	+.50
Boiler..................	0.7	33.3	0.2	9.5	0.286	—.71
	2.1	100.0	2.3	109.5	1.095	+9.5

Then the total cost of the labour and repairs of the turbine station boiler room, as compared to the engine station boiler room, was as given in Table VI.

6.—The handling over in storage field in case fuel heats.

7.—The maintenance of all machinery in the coal handling system.

All of the above items are charged

TABLE VI.

Boiler Room.	Percentage Total Cost K. W. H. Engine Sta.	Percentage of Total Boiler Room Cost.	Percentage of Total Cost K. W. H. Turb. Station to Engine Sta	Percentage of Total Cost Turbine to Engine.	Ratio Turbine to Engine.	Turbine to +=Increase. Engine to —=Decrease.
Total labour	8.5	80.2	4.9	46.2	0.576	—42.3%
Total repairs	2.1	19.8	2.3	21.7	1.095	+9.5%
Total cost	10.6	100.0	7.2	67.9		

I have gone over the boiler room expenses in rather a detailed manner, for the reason that in making a comparison of two stations, one showing better as to cost of operating and maintenance than the other, it seems to me to be quite necessary to show just where and how the saving is effected in the one case, so that such credit as may be due to improvements in apparatus should not be misplaced or diverted to wrong channels, by reason of making the sweeping assertion that the difference in total cost between the two power houses is a certain percentage, and

to "Stock Fuel," and at the end of each month the total cost, divided by the short tons of coal used, gives the price per short ton, and the amount is then charged to "Operating Fuel," and "Stock Fuel" is credited.

As I have said before, all fuel is weighed in each fire room before going to the fires. Before beginning a comparison on the cost of operation and maintenance of the engine and turbine rooms proper, I will say that in both of these rooms are located the auxiliaries for such units as are operated for the generation of current, and the boiler feed pumps

also are there, so that, broadly speaking, everything in the nature of moving machinery, whether steam or electrically driven, is directly under the observation of the watch engineers.

Exception only to the above are the motors which operate the mechanical stokers in the turbine station boiler room. In other words, the facility afforded in each room for men to operate quickly and accurately is good, and with everything taken into consideration the facilities are very similar. Excellent opportunity is thus given for a fair comparison on the labour cost of operating in both locations.

It is proper to explain at this time that before the turbine station was erected the services of the chief engineer, the chief operator, and their respective first assistants, were charged wholly to the engine station, and at the present time are divided equally between the two stations, and this distribution of labour will be fully set forth in tabulated form in this article.

We began at the boiler room end by making a comparison of the labour, and therefore we will begin with this item in the generating rooms also. Table VII. gives the number of men engaged in the operation of steam apparatus in the year 1904 in the engine station, and year 1905 in the turbine station, and, as in division of fire room labour, we will assume the engine room labour to be 100 per cent. as the standard.

For the operation of the electrical portion of the engine station in 1904 nine men were employed, and as the two power houses are located on either side of the operating room, it was possible to operate in 1905 both the engine and turbine stations without increasing the pay roll, and the labour cost has been divided equally between the two stations, and that being the fact, it does not seem necessary to tabulate.

I will say, however, that the electrical operating force is composed of the following men:—

Chief operator	1
Asst. operator	1
Watch operators	3
Asst. watch operators	4
Total men	9

The engine station contains the motor-generators for city lighting. This is practically a division in itself, in that none of the men employed on the floor is employed for anything except that work; in other words, they do nothing toward operating any of the electrical generating units, and are not employed on the switchboards for regulating or other purposes. It is a fact also, that the two stations are provided with three telephone operators, one janitor and three watchmen, and these all are charged pro rata between the generating and the electrical room expense of each of the two stations; in other words, their expense is divided into four equal portions, one-fourth to each of two divisions in two stations.

In a tabulated form which appears later in this article all labour will be shown, that is to say in the columns showing the proportion of each labour cost to the total generated cost, all of the labour will have been included, whether it has previously been shown in comparisons of labour or not, and it should be borne

TABLE VII.

	1904. Engine.	1905. Turbine.	1904. Engine % of Total.	1905. Turbine % of Engine Total.	Ratio Turbine to Engine.	Decrease Turbine.
Chief engineer	1	0.5	4.2	2.1	0.50	50%
Asst. engineer	1	0.5	4.2	2.1	0.50	50%
Watch engineers	3	1.5	12.5	6.3	0.50	50%
Condenser men	1	0.0	4.2	....	....	100%
Oilers	13	7.0	54.	29.1	....	46%
Cleaners	4	1.0	16.7	4.3	0.25	75%
Repair men	1	.5	4.2	2.1	0.50	50%
	24	11.0	100.0	46.0	.460	54%

TABLE VIII.

Accounts.	Account Number.	Eng. Sta. 1904 % of Each Account to Total Cost.	Turb. Sta. 1905 % of Each Account to Total of Eng. Sta.	Ratio Turbine Station to Engine Station.	+=% Increase. —=% Decrease
Fuel	O 41	60.3	65.5	1.086	+8.6
Water	O 42	5.1	1.3	0.255	—74.5
Oil and waste	O 43	1.4	0.7	0.500	—50.0
Total labour	....	24.2	13.4	0.554	—44.6
Boiler labour	O 44	8.5	4.9	0.576	—42.4
Engine labour	O 45	9.0	5.2	0.578	—42.2
Electrical labour	O 46	6.7	3.3	0.493	—50.7
Battery labour	O 47	....	....	......	......
Battery supplies	O 48	....	....	......	......
Sundries	O 49	1.8	1.1	0.611	—38.9
Total operating	....	92.8	82.0	0.884	—11.6
Station buildings	R 52	.7	0.3	0.428	—57.2
Mechanical apparatus	R 53	2.1	1.1	0.524	—47.6
Grates	R 54–02	1.4	2.1	1.500	+50.0
Boilers	R 54–09	0.7	0.2	0.286	—71.4
Engines	R 55	0.9	0.2	0.222	—77.8
Dynamos	R 56	1.1	0.2	0.182	—81.8
Electrical apparatus	R 57	0.3	0.3	1.000	00.0
Batteries	R 58	....	....	......	......
Total repairs and renewals	....	7.2	4.4	0.611	—38.9
Total cost of total station	....	100.0	86.4	0.864	—13.6
Kilowatt hours manufactured		100.0	89.3	0.893	—10.7
Coal consumed, short tons		100.0	99.0	0.990	—1.0
Coal consumed per K. W. H.		100.0	111.0	1.100	+11.0
Average cost coal short ton		100.0	98.0	0.980	—2.0
Load factor		100.0	1.09	1.090	+9.0
Total cost per K. W. H.		100.0	86.4	0.864	—13.6

in mind that the labour omitted in previous tables, but appearing in those to follow, does not in any way affect the accuracy of comparison, because it is distributed equally to four distinct accounts in the operating expenses of the two stations.

I would also add that we make a practice of effecting minor repairs with the operating force in each division, but we do not carry a repair force in the generating department, having found by experience that it is less expensive to call in various firms who are equipped with tools and help, which give prompt and efficient service in that line.

All the testing is done by our own laboratory, on which we draw orders the same as if it were an outside concern, and these orders are charged direct to the operating accounts of the generating system.

Table VIII. gives a comparison of the turbine station and that operated by engines, using 100 as the total cost for the year for the engine station, and in this table is included all labour of any and every nature, as well as every other expense necessary to operate and maintain a generating system.

The operation of the turbine station from which the above records have accrued was not satisfactory from several points of view in 1905, and for the following reasons:—

First, we had not sufficient transformer capacity between stations to enable us to load the turbines economically, and at the same time insure continuity of service. I may say in explanation of this that the engine station generates at 2,300 volts and the turbine at 6,900, and the transformer arrangement is such as to admit of changing load of either station to the other to the extent of the transformer capacity.

Second, the turbine station was operated commercially for the first time in October, 1904, and the construction of the station was not complete, and there were a great many interruptions of operation, not due to the units, but to changes that necessitated taking units out of service. The banking of fires was thus made necessary, and consequently a great loss of heat value was incurred.

TABLE IX.

Accounts.	Account Numbers.	Engine Sta. Last 9 Mos. 1904 % of Each Account to Total Cost.	Turbine Sta. First 9 Mos. of Fiscal Year % of Each Account to Total of Engine Sta.	Ratio Turbine Sta. to Engine Station.	+=% Increase. —=% Decrease
Fuel	O 41	58.7	61.6	1.049	+4.9
Water	O 42	5.1	1.3	0.255	—74.5
Oil and waste	O 43	1.4	0.5	0.357	—64.3
Total labour	....	25.3	10.7	0.423	—57.7
Boiler labour	O 44	8.8	4.0	0.454	—54.6
Engine labour	O 45	9.5	4.1	0.431	—56.9
Electrical labour	O 46	7.0	2.6	0.371	—62.9
Battery labour	O 47	....	....	.....	......
Battery supplies	O 48	....	....	.....	......
Sundries	O 49	2.0	1.0	0.500	—50.0
Total operating	....	92.5	75.1	0.812	—18.8
Station building	R 52	1.0	0.2	0.200	—80.0
Mechanical apparatus	R 53	1.2	1.3	1.083	+8.3
Grates	R 54–02	1.8	1.8	1.000	......
Boilers	R 54–09	0.8	....	.....	—100.0
Engines	R 55	0.9	0.2	0.222	—77.8
Dynamos	R 56	1.5	*0.2	.....	—100.0
Electrical apparatus	R 57	0.3	....	.....	—100.0
Batteries	R 58	....	....	.....	......
Total repairs	....	7.5	3.3	0.440	—56.0
Total cost of total station	....	100.0	78.4	0.784	—21.6
Kilowatt hours manufactured		100.0	115.4	1.15	+15.4
Coal consumed short ton		100.0	122.2	1.22	+22.2
Coal consumed per K. W. H.		100.0	106.0	1.06	+6.0
Average cost per short ton		100.0	99.1	0.991	—0.9
Load factor		100.0	108.5	1.08	+8.5
Total cost per K. W. H.		100.0	78.4	0.784	—21.6

* Credit.

In the meatime improvements were being made on parts of units of the turbine type, and it was finally decided to incorporate some of them in connection with the units then in operation, which, of course, caused more interruption of operation; but it was time well spent.

At the beginning of the fiscal year July 1, 1905, we were fairly well completed with reference to the construction of the station, and had an opportunity to "work the units out" under fairly reasonable conditions. As a matter of fact, in the nine months of the fiscal year ended April 1, 1906, we manufactured 94.1 per cent. as many killowatts as we did in the twelve months of the calendar year 1905, and with practically uninterrupted operation, with the exception of some instances of steam line repairs and condenser tube troubles which are likely to occur to a greater or less extent.

The repairs were small in the calendar year 1905, but the first nine months of the fiscal year show very much less; so also does the cost of operating, and the total generated cost per kilowatt-hour.

As for the turbine units themselves, I have no hesitation in saying that as load carriers they are "gluttons," and the maintenance is exceedingly small in comparison with any other unit that we operate. Table IX. gives the operation of the turbine station for the first nine months of the fiscal year, July 1, 1905, to April 1, 1906, in comparison with the engine station for the last nine months of the calendar year 1904, for that portion of 1904 gave the engine station the best load—as a matter of fact, the best load factor.

Table X. shows the division of labour in both of these power houses at the present time, so that it may be made plain how the services of every man employed are charged on the pay roll, and also to show that every person that is connected in any way with operation of the generating system is charged to it.

I may add at this time that in three recent months of the fiscal year, we were obliged to use field-

stored coal which had been on the ground for more than a year. This was very dirty. This condition was brought about by reason of the difficulties of the coal people, on whom we principally depend for our fuel, and additional to that fact shipments were much delayed, on account of heavy weather at sea.

A few words with reference to the "Increases" and "Decreases" as shown in the totals in Table IX. The "fuel," for instance, looks high for the turbine station as compared with that of the engine station, but in the very next account, which is "water," we find a heavy reduction in cost. Just what this means may be found by adding together the figures which represent the proportions of "fuel" and "water" to the total cost of a killowatt-hour, in the engine station for 1904, as per the table for nine months, and we find we have for the sum of the two items 63.8.

Add the same corresponding items in the same table for the turbine station, and we find the result to be 62.9.

Total cost fuel and water, engine station	63.8
Total cost fuel and water, turbine station	62.9
	0.9

This represents 1.41 per cent. less expense in operating of the turbine station.

The above is not quite true, because we also find in the same table that the cost of fuel for the turbine 1905-6 was 0.9 per cent. less than in the case of the engine station for 1904, and to correct and obtain a true result, the fuel and water figures for the turbine station should be $61.6 + 0.9 + 1.3 = 63.8 =$ total comparative cost of "fuel" and "water" for the turbine station for 1905-6.

The price of boiler feed water is the same for both stations, and always has been within the writer's experience, and it is only by difference in conditions that vary the price of coal delivered in the fire room, that the costs of these two items in both stations are exactly alike, and that under exact comparative conditions the excess in the cost of the "fuel" is offset by the decrease in the cost of boiler feed water.

TABLE X.—Distribution of Labor on Payroll for the Engine and Turbine Stations, Month of March, 1906.

O44 Boiler Room Labour	Engine Station.	Turbine Station.	Total Men.
Chief engineer...............	0.25	0.25	0.50
Asst. engineer...............	0.25	0.25	0.50
Fire room engineer...........	1.00	1.00	2.00
Water tenders................	3.00	3.00	6.00
Firemen......................	4.00	5.00	9.00
Repair men...................	0.00	1.00	1.00
Coal passers.................	1.00	3.00	4.00
Total boiler room labour ...	9.50	13.50	23.00
O45 generating room labour			
Chief engineer...............	0.25	0.25	0.50
Asst. engineer...............	0.25	0.25	0.50
Watch engineers..............	1.50	1.50	3.00
Oilers.......................	5.00	6.00	11.00
Condenser men................	1.00	0.00	1.00
Repair men...................	0.50	0.50	1.00
Cleaners.....................	2.50	1.50	4.00
Telephone operators..........	0.75	0.75	1.50
Janitor......................	0.25	0.25	0.50
Watchmen.....................	0.75	0.75	1.50
Total gen. room labour.....	12.75	11.75	24.50
O46 electrical room labour			
Chief operator...............	0.50	0.50	1.00
Asst. operator...............	0.50	0.50	1.00
Watch operators..............	1.50	1.50	3.00
Asst. watch operators........	2.00	2.00	4.00
Telephone operators..........	0.75	0.75	1.50
Janitor......................	0.25	0.25	0.50
Watchmen.....................	0.75	0.75	1.50
Total elec. room labour....	6.25	6.25	12.50
Total divided labour both stations................	28.50	31.50	60.00

The decrease in proportionate cost of oil and water is easily accounted for when we recall that in one case, that of the engine station, we are using cylinder oil for a 9,000 K. W. plant with six cross-compound engines, and auxiliaries, as against a 10,000 K. W. turbine plant with cylinder oil in use for auxiliaries only.

The "boiler labour" decrease is accounted for principally by the fact that in one case we have hand-fired furnaces, and in the other mechanical stokers, but in both cases a close watch is kept on the amount of labour employed. The "engine labour" decrease is due to the fact that a cross-compound engine of 2,240 H. P. is not oiled well and economically with less than one man on each of three watches, while in the turbine room the auxiliaries are nearly all there is to look after in this line of work.

The "electrical labour" decrease is

due to the fact that the electrical controlling devices for both power houses are so situated (between the two) that we have not found it necessary thus far to increase the labour expense in order to operate successfully.

"Sundries" is rather an indefinite account, and is subject to such charges as cannot properly be charged to accounts more clearly defined. It contains such charges as boiler compound, petty cash, etc., but nevertheless it is purely an operating account, and liable to small variation.

On "repairs station buildings"—the engine station is older than the turbine structure and naturally would call for a greater outlay for repairs, although our practice is to make repairs on everything the moment they seem necessary, and not let them multiply or enlarge.

"Repairs mechanical apparatus," include everything which is a part of the generating system, but not parts of moving machinery, as, for instance, steam line, condensers, tools, etc.

The increased cost of grate repairs is due to the fact that the boilers do heavy work, and we use a coal of high carbon value, as the analysis will show, and under these conditions, which are the same as in the engine station, we have so far been unable to hold the expense to any lower level than is shown in the table.

There is nothing to complain of, however, if we take into consideration the decrease in cost of boiler room labour with mechanical stokers in use, as against a less repair cost and a very much higher cost for labour with hand-fired furnaces.

Boiler repairs should not vary much in either case, except there be valves to be renewed or some similar expense, which comes once in a great while and which naturally might occur at very different periods, where one station has been in operation seven or eight years, while the one in comparison has been operated a much shorter period.

Repairs on turbines will always, in the writer's opinion, be less than on reciprocating engines. That is the deduction after operating the turbine units nearly two years, and keeping a close watch on this item of expense.

Of course, I refer to the turbines in the power house under comparison, as I have no reason for comparing with any other type.

With reference to repairs on "dynamos" in the turbine station, experience with this portion of the turbine unit indicates that repairs will be exceedingly small; in fact, the tables show them to be such, but I refer especially to the future.

Repairs on "electrical apparatus" are very small, and refer to switchboards, oil switches, instruments, and in fact all apparatus within the territory covered by the electrical operating room.

Of "batteries" there is nothing to say, as the only one connected with the turbine station is a small one floating on the excitation system, and the expense of maintenance thus far is negligible.

Concluding, I will say that a fair and true commercial comparison of the two types of stations is what I have intended to give, and I have shown that comparison by using records which have accumulated day by day, in the actual commercial operation of one of the large lighting and power systems of the country, and one of the successful ones from a financial point of view.

WHAT CAN AMERICA LEARN FROM GREAT BRITAIN IN TRANSPORTATION?

GROWTH OF THE MOTOR-TRAIN AND MOTOR-BUS

By Archibald S. Hurd

IT may astonish the American public to learn that they can gain any hints from Great Britain in the matter of transportation. The fact which everyone realizes is that Great Britain owes a great debt to American engineers and financiers. It was they who first convinced the British people that a large part of their lives was thrown away in slow and cumbrous traveling, and it was they who preached the sound policy of the "scrap heap" for out-of-date machinery.

For years past British expresses between distant towns have rivalled the best services in America and on the Continent of Europe, but it needed the American engineer to teach the six millions who live in London the wastefulness of the slow and inconvenient methods of getting to and from their work which existed a few years ago, and still exists practically throughout the whole of the British metropolis which lies to the north of the Thames.

Probably the population in Northern London amounts to two and a half or three million persons, and those who have business in the city go to their shops or offices either by heavy, noisy, horse-drawn buses, by tedious horse trams or by trains which stop at practically all intermediate stations, and take from thirty to forty minues to accomplish a journey of four to six miles. Those who live on the heights of Hempstead and desire to reach the city by train, have to travel by a circuitous route to Dalston and then back again to the East End before the train bends in to the central district, making an irregular three-quarters' circle.

There is a direct route to the city by tramcar. The distance is just over four miles, and as the cars are drawn by horses and may be stopped at any point by passengers who desire to enter or leave, it is not astonishing that the journey occupies three-quarters of an hour. Throughout Great Britain, although provincial towns are better served than the capital of the British Empire, parallel instances of slow, expensive and inconvenient means of transit may be found. America can learn nothing from Great Britain in this respect.

The American capitalist and his at-

endant engineer appeared on the scene a few years ago and introduced the "tube" railway running from the Bank of England to Shepherd's Bush, a southern suburb. The project was one of the sensations of the year in Great Britain. The Englishman loves to travel in the open air, but when the choice lay between a snail-like omnibus, London's travelling Noah's Ark, and the quick railway service of the "tube" railway, the business man was compelled to choose the newer and swifter means of locomotion.

The success of the "tube" railway was so instantaneous and remarkable, that a score of other schemes were immediately elaborated and Parliamentary sanction was sought. Competition between the "tube" railway and horse-drawn trams and buses, it was at once seen, could end only in favour of the former. Traffic receipts of the great tram and bus companies fell to an alarming extent, and those responsible at once realized that the alternative to bankruptcy was some better form of traction.

It may be ascribed by Americans to insular prejudice, but there is every reason to believe that in ten years' time London will be served in the matter of quick communication between its various suburbs and its great business center better than any city on the American continent. The financial collapse which threatened the old-fashioned bus and tram companies led to a series of experiments with motor-buses, with the result that various companies are placing on the streets of London several hundred efficient cars.

Some of the new vehicles of the London Road Car Company are driven by petrol motors of 24 horse-power, of the Durkopp and Germain types, and carry 32 passengers, whilst others are propelled by steam (generated by the combustion of crude petroleum) of 16 horse-power, by Clarkson, of Chelmsford, carrying 14

A MOTOR-TRAIN "HALTE" ON THE GREAT WESTERN RAILWAY

ONE OF THE MOTOR-OMNIBUSES OF THE GREAT WESTERN RAILWAY. LUGGAGE IS CARRIED ON TOP

or 15 passengers. The speed of these vehicles is 50 per cent greater than that of the horse-cars, and two motor cars do the work of three horse cars, whilst the 50 new omnibuses ordered by one company will enable from 600 to 700 horses to be dispensed with and a great saving of space in depots and stables to be effected. The cost of maintenance and running the new cars is reassuring, especially as the cost of tires is working out at a lower figure than was once feared.*

Unlike most American cars, practically all the buses and trams in Great Britain have seats on top. There is, as already mentioned, nothing which the English enjoy so much as being able to travel in the open air. Probably the outdoor life which Londoners, like the residents of other big towns in Great Britain, lead, is responsible in no small measure for the fact that the British metropolis, in spite of its congestion of population and its huge army of desperately poor residents, is the healthiest city in the world. A ride on an outside seat of a tram or a bus is a luxury in which the poorest traveler indulges in the coldest weather. It is not difficult to see, in view of this love for fresh air, what the probable outcome will be when "tube" railways and quick electric tram-cars and buses will be in direct and well-developed competition a few years hence.

The "tube" trains have been constructed at an immense capital outlay—a charge which the trams have to bear in far less degree and the buses not at all, though the wear and tear of buses is greater than in the case of trams or trains. Already on a small scale the verdict has gone in favour of the road vehicle. A service of motor-buses runs daily between Shepherd's Bush and Oxford Circus, and Londoners who were astonished at the quickness and cheapness of the "twopenny tube" are bewildered to find that they can travel by bus for

* It may be interesting in connection with this to refer to the article on "Motor Omnibuses for Public Passenger Service" in the May number of this magazine.—THE EDITOR.

ONE OF MANY PUBLIC MOTOR-OMNIBUSES NOW RUNNING IN LONDON

short distances as fast as the underground railway can carry them, at just half the price.

The success which has thus far attended the motor-omnibus has been so instantaneous and complete that already the opinion is expressed that the "tube" railways, which are now spreading out in all directions, will, in a few years, have to fight for existence. It is even doubtful if the present policy of electrifying road tramways at great expense and inconvenience will be pursued. In view of the progress which has been made in the development of the motor-bus, it is believed in Great Britain that in future a large portion of the passenger traffic will be carried by these means, and that the policy of laying tram lines and incurring the heavy expense incident to installing the conduit or trolley system will be saved.

Another development in the dealing with traffic may be seen in south London, where the London United Electric Tramways Company has laid a network of lines. The presiding genius (the word is used advisedly) is Mr. J. Clifton Robinson, who assisted George Francis Train in laying the initial tramway in Europe forty-five years ago, and since then has become known as the director of the pioneer system of cable and electric tramways at San Francisco and Los Angeles. He has revolutionized south London, and now has under his control nearly eighty miles of tramways which bisect and intersect the most beautiful parts of the south-western districts of London.

The magnificent cars of his company run through the beautiful Thames Valley to Hampton Court, flash through Twickenham to Richmond Bridge, or land the passenger as far west as Uxbridge. The result of Mr. Robinson's enterprise was seen in the second year of the working of the company, when, on the average, every man, woman and child in the suburbs touched by his system boarded the cars 126 times. While the electric tramway can be constructed only at great expense and is therefore held by some—

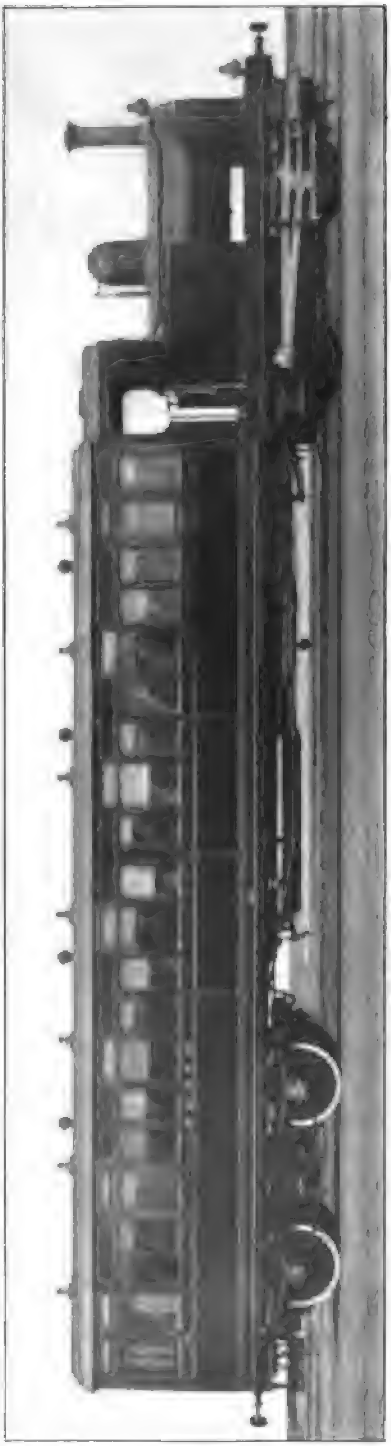
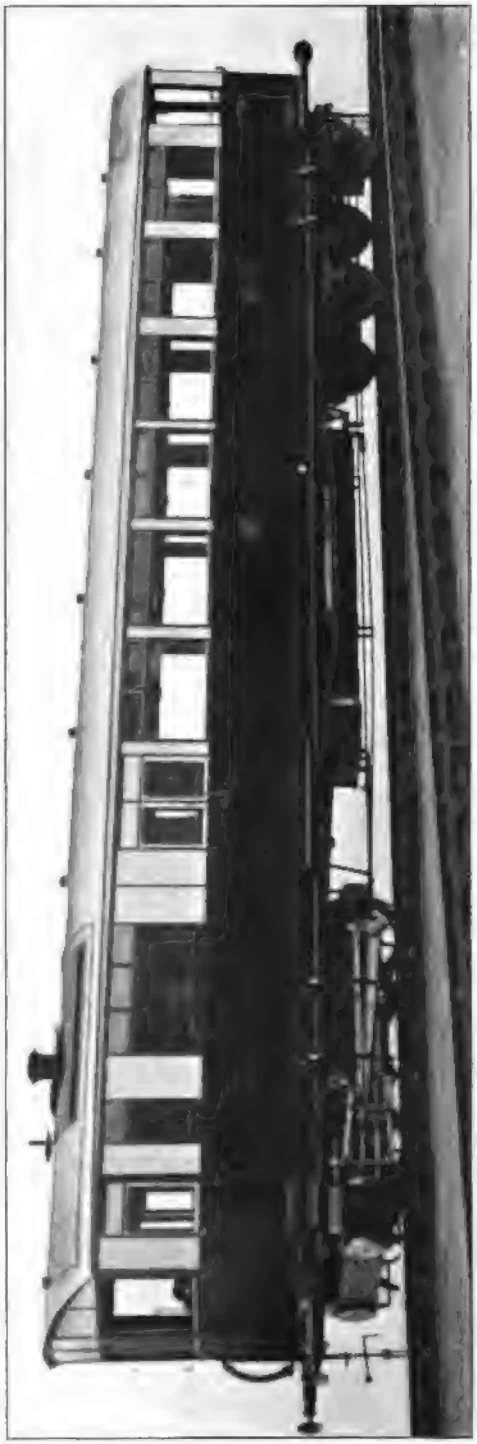


FIG. 13.—STEAM MOTOR-CARRIAGE WITH SEPARATE LOCOMOTIVE ON THE GLASGOW & SOUTH WESTERN RAILWAY. DESIGNED BY MR. JAMES MANSON, LOCOMOTIVE SUPERINTENDENT OF THE G. & S. W. R.



RAIL MOTOR-CAR OF THE GREAT WESTERN RAILWAY CO., DESIGNED FOR LOCAL TRAFFIC CARRYING 52 PASSENGERS

though not by Mr. Robinson—to be unable to compete successfully with the motor-bus, the cost is nothing in comparison with that involved in the construction of a tube railway. Consequently travelling is cheap.

A workman can travel for five miles by tram for a penny, and in some cases as much as seven miles for one penny, and the average fare for the whole system works out at less than one farthing a mile. He is conveyed to and from his work with dispatch and even in luxury, for the cars closely resemble the best saloon carriages on British railways. When the line was opened, Mr. A. J. Balfour, the Prime Minister, prophesied that such means of quick transit would prove of immense importance in the solution of the problems created by the congestion of population within the inner circles of London.

As Cook brought within the means of the middle classes in Great Britain facilities for travelling all over the world, so the tramway is providing the poorest in London with facilities for enjoying a delightful day's holiday at nominal expense.

It is no exaggeration to say that Mr. Robinson has worked a revolution in London south of the Thames. The working man and his family on pleasure bent, who have exhausted the depths of Kew, may take a "round" ticket enabling them to make the "grande tour" through all that is most charming in the country lying to the south of London, where the advent of the cars has already led to an immense growth in the population, which is streaming outward from congested districts as quickly as houses can be built. In the great provincial towns, such as Bristol, Bournemouth, Plymouth, and Portsmouth, enterprise on the same lines is being shown, and the popularity of the double-decked cars has been signally proved.

A further interesting development which was first seen in provincial towns is the small self-contained motor-train for dealing with local traffic between the great centres of population and the outlying suburbs. Throughout Great Britain tramways and light railways have been introduced in the past few years, and as these competitors have invaded districts served by the existing railway companies, the latter corporations have had to cast around for some means for meeting the rivalry. Without exception the upward tendency of railway passenger receipts was checked by the rivalry of trams and light railways in urban districts, and in many cases the falling-off in revenue was most serious.

How this competition was to be met was the problem that faced the railway managers. A solution has been found in the self-contained motor train. The claim to the honour of being the pioneer in this direction is disputed, but among the first to adopt the new system of dealing with local traffic was Mr. J. C. Inglis, a well-known engineer and the general manager of the Great Western Railway, one of the greatest corporations in Great Britain.

In Plymouth, Swansea, and elsewhere the trams were robbing the line of its local traffic, but the motor-train has worked a revolution. The type of car varies, but the general character of the most popular makes now in use in Great Britain may be seen from some of the accompanying illustrations. The essential principle is that small self-contained trams can be run frequently between towns and suburbs at small cost. Such services are profitable as feeders to the main line of a system where an ordinary train would result in heavy loss, and in order to tap new intermediate districts small stations or "haltes" have been provided at slight expense so that every one living in the suburbs of towns to which the motor train has been introduced has a station practically within stone's throw of his home. See Page 513.

The success of the motor-train has led to a great development in coun-

try districts of the motor-omnibus and motor-lorry for the conveyance of passengers and market produce, respectively, to the nearest railway station, and by this means the Great Western Company, in particular, has encouraged a most promising field of excursion traffic, and assisted the small farmer in bringing his goods to the market. These innovations have proved a success from both a social and financial point of view. Mr. Charles Aldington, of the Great Western Company, has explained that in some parts of the country county councils have effectively seconded the efforts of the company by delegating skilled lecturers to demonstrate to farmers' wives and daughters the virtues of cleanliness in buttermaking, care in preparing poultry for the table, and neatness in packing.

While the promotion of a "light railway" scheme involves months of careful preparation and inquiry on the part of controlling authorities before beginning to carry out the works, a motor service can be started at the shortest notice along those natural arteries—the King's highways. A good motor service is as flexible as an elephant's trunk, and as capable of picking up things both small and large. It will flourish on crumbs that a self-respecting railway would despise, and a combination service of motor-omnibus and motor lorry will sweep up from the country-side traffic ranging from a load of broccoli to a cyclist with a punctured tire.

One benefit conferred by motor service is that manufacturers are enabled to utilize cheap and suitable sites for factories, the motor-lorry keeping them in touch with the gathering and distribution systems of the country. Apart from the purely commercial advantages of the public service motor-vehicle, there is a legitimate sphere of operation for the motor-car in conjunction with railway holiday traffic. Railway companies vie with one another in advertising the most attractive holiday resorts for the multitudes, and what more bracing pleasure can be desired than a trip on a smart motor observation car through the beauties of South Devon, over the rugged moors or along the wild coast to Land's End—inferentially bringing grist to the railway mill in the price of a tourist ticket from London, the Midlands, or the North, while this holiday element benefits the locality favoured by the tourist.

For water use, there are motor boats and launches built to suit lake, river and salt water work, and it will be possible by means of these to open up new and charming rounds of travel for the tourist, who is always seeking new ground; and the brain of the general manager of the Great Western Railway Company has conceived a future for motor boats in resuscitating the fortunes of some of the many dormant canals of the country.

So far as passenger travel is concerned, the petrol engine is generally considered the most suitable, and the whole of the Great Western Company's cars are of this type, with the exception of three steam cars at Wolverhampton. The bodies of the cars used by the different companies who have embarked on his "feeder" system are of different types, designed to accommodate various classes of traffic.

1.—Open observation cars, carrying 24 passengers, for summer pleasure traffic.

2.—Closed omnibuses, with roofs strong enough to take 15 cwts. of luggage, parcels, or goods, and seating 18 passengers.

3.—Double-decked omnibuses, of the type familiar in London streets, carrying 36 passengers.

4.—Open wagonettes, seating 22 passengers, and fitted with luggage roof.

5.—Composite bodies, seating 12 passengers inside, with a compartment available for luggage, mails, or goods, or for passengers desiring to

smoke. By these methods those who cater for public service in town and country in Great Britain are competing for custom and bringing the railway within easy reach of the most attractive villages and the public are gaining the advantage, while experience has already proved that good dividends are to be earned by the tram, bus, and railway companies. Competition is the soul of a commercial community. The rivalry has only recently begun, and those who are looking on, and see perhaps most of the game, appreciate that the contest between the various forms of locomotion is destined to become increasingly severe.

SEEING BY ELECTRICITY

By William Maver, Jr.

ALMOST simultaneously from two different places in the United States the invention of a device for seeing at a distance by electrical means is announced by two different inventors. Somewhat strange to say, the name adopted by each inventor for his device is "Televue." The names of the two inventors are J. B. Fowler and William H. Thompson.

A non-technical description of Mr. Fowler's device in one of the electrical papers shows a woman speaking into a telephone transmitter, while at the side of the transmitter is a projection akin to that of a hand stereoscope. The idea is that the apparition of the person at the distant end of the wire will be seen within this projection. It is said that four wires are at present required to accomplish the speaking and seeing, but that eventually two wires only will be necessary. It is also said that natural colours are reproduced in the apparatus. Complete details of the operation of this interesting apparatus are withheld, it is said, for certain reasons connected with Patent Office matters. In the meantime, however, it is reported that a company has been organized to push the scheme, and stock in the company will be offered to the public.

Mr. Thompson does not appear to have progressed so far with his invention as Mr. Fowler, but it is stated on Mr. Thompson's behalf that his device will be an improvement on the other one.

In the absence of details it is obvious that no opinion can be expressed as to the value of the claims of these gentlemen. It is well established that the problem which they have set out to solve is not an easy one. Attempts without number have been made to solve it by men well equipped for the purpose, but thus far without success.

Not long ago M. A. Nisco, of Belgium, made a careful study of many of the methods that have been proposed for seeing at a distance electrically, and concluded that none of the devices thus far experimented with possesses the necessary requirements for successful operation.

In the majority of the methods for transmitting sight to a distance, that property of selenium by which its electrical resistance varies with the intensity of the light thrown upon it, has been employed, but the use of this substance for this purpose has not hitherto met the expectations of inventors.

As a result of Mr. Nisco's study of the subject, he believes that a system constructed somewhat as follows would give practical results:—

Let a sensitive screen be prepared by coating a metallic net with an insulating varnish. Into the meshes of the net copper wires are inserted before the insulating material hardens. The surface is then filed off smooth and a coat of selenium is spread over the net, this forming a connection between the net and the copper wires. The selenium is then treated in such a manner as to crystallize it, which brings it into the required sensitive condition.

The copper wires are led into a hollow ebonite cylinder and are then brought to the outer surface of the cylinder through holes that are arranged to correspond to the position of the copper wires in the netting. The holes are arranged in spirals around the cylinder, and a steel blade is caused to pass around the cylinder at the rate of 600 revolutions a minute. As it does so, the blade makes momentary contact with the protruding copper wires, ten times per second. The blade, the copper wires and the metallic screen are in an electric circuit with a battery and a telephone receiver. To this telephone is connected a minute microphone which repeats the variations of current that may be set up in the selenium circuit into the transmission line.

At the receiving station a second telephone receiver, by means of another suitably arranged microphone, repeats the variations of current into a local circuit, which is arranged to produce a spark, the luminosity of which depends on the strength of the current, which latter, in turn, varies directly with the intensity of illumination at the selenium screen at the transmission station.

The spark-gap is placed within a cylinder which is provided with slots arranged spirally around the cylinder in a manner corresponding to the arrangement of the copper wires in the transmitting cylinder. The slotted cylinder revolves in unison with the blade at the sending station.

If then, says Mr. Nisco, a picture be thrown upon the metallic screen while the apparatus at each station is operating synchronously, the light of each spark at the receiving station will be cast on a receiving screen in a manner capable of producing an illuminated image of the picture at the transmitting station. The method just described produces only variations in illumination, and it requires two wires, one for maintaining synchronism between the moving apparatus, the other for transmission of the variable currents.

While Mr. Nisco's plan thus outlined does credit to his ingenuity, its practicability appears rather problematical. It is not altogether unlikely, however, that Mr. Nisco's suggestions have formed, and will form, the basis of the efforts of numerous aspirants for fame and wealth in this direction. The public, however, should take all statements of successful accomplishments of this nature *cum grano salis*.

THE ADVANTAGES OF PURCHASED ELECTRIC POWER

By H. B. Gear

IT was not long after the establishment of the historic electric central station on Pearl Street, in the city of New York, that the owners of the new enterprise realized how advantageous it would be to themselves and to the proprietors of small shops to sell the electric current derived from the lighting dynamos for power purposes.

Mr. Edison, having put the incandescent lamp on a commercial basis, directed his attention to the development of the electric motor, which soon became a commercial article. It is a noteworthy fact, that many of the motors made according to Mr. Edison's design are still in operation, having given reliable and satisfactory service for upward of fifteen years.

The small manufacturer was not slow to recognize the superiority of this new form of motive power, over the small steam or gas engine then in general use. The prospect of freedom from the heat and dirt incident to a small power plant and the possibility of locating shops on upper floors at reduced rental was very alluring, and the electric motor was soon started on its way as a revolutionizer of small manufacturing establishments.

With the establishment of central stations in other cities the movement became one of wide extent, increasing year by year and soon spreading to Great Britain and the Continent. In the decade from 1886 to 1896, the movement was mostly confined to those establishments whose requirements did not exceed 15 to 20 H. P.

In a description of central station developments in one of the largest American cities, which appeared in an electrical journal in the year 1896, a writer pointed with pride to the fact that the company's power business was growing rapidly, and that they had one customer whose motor installation aggregated 110 H. P., a single unit being as large as 20 H. P. To-day, in the same city, a 100-H. P. installation excites no comment, and this same central station company supplies half a dozen motor installations which aggregate upward of 1000 H. P.

Ten years ago the consumption of current for power purposes was only 28 per cent. of that used for lighting, while it is now 60 per cent. The rate of increase has been more rapid in the last few years than in the early part of the decade, and is keeping pace with the growth of electric lighting very evenly.

The reasons for this rapid increase in the rate of growth of electric power consumption during recent years are various, but there are perhaps three which may be considered most influential:—

1. The gradual reduction of the rates of charge made by central stations for electric power.

2. An increasing appreciation on the part of power consumers of the advantages of central station power, available at all hours.

3. An enormous expansion of power consumption generally, in which electric power has enjoyed the lion's share.

The rapid growth of the central station industry has resulted in equally rapid increases in the size of generating plants. This, in turn, has brought reduced generating costs and reduced selling prices. The reduced

selling prices are also largely the result of a system of charging devised by Wright, in Great Britain, and known among the fraternity as the "Wright Demand" system of charging. It is a differential system and is sometimes called the "differential rate." The basis of the system is the provision of a higher rate for a portion of the power used, and a lower rate for the remainder.

The object of the "high-rate portion" is to reimburse the producer for the fixed charges on the investment made for the consumer's benefit. As fixed charges go on the same whether power is used two hours or ten hours each day, the high rate applies to the current used during the first hour of each day. The current used during the succeeding hours is charged at the low rate, since this portion covers only operating expenses which are less than the fixed charges. This system is obviously most advantageous to the long-hour user, and has lowered the rates to a large class of power consumers who operate their plants from eight to fifteen hours, or more, a day. There are other modifications of the Wright system which are established upon the same basis, and differ only in the details of arrangement of high and low-rate portions.

The "differential rate" has been the basis of some criticism on the part of those who have imperfectly understood its working, but it is daily becoming more generally recognized as the only system which gives all consumers the same rate under the same conditions. The long-hour user of a small amount of power on the dif-

FIG. 1.—A STEEL BEAM SAW DRIVEN BY A 75 H. P. ELECTRIC MOTOR

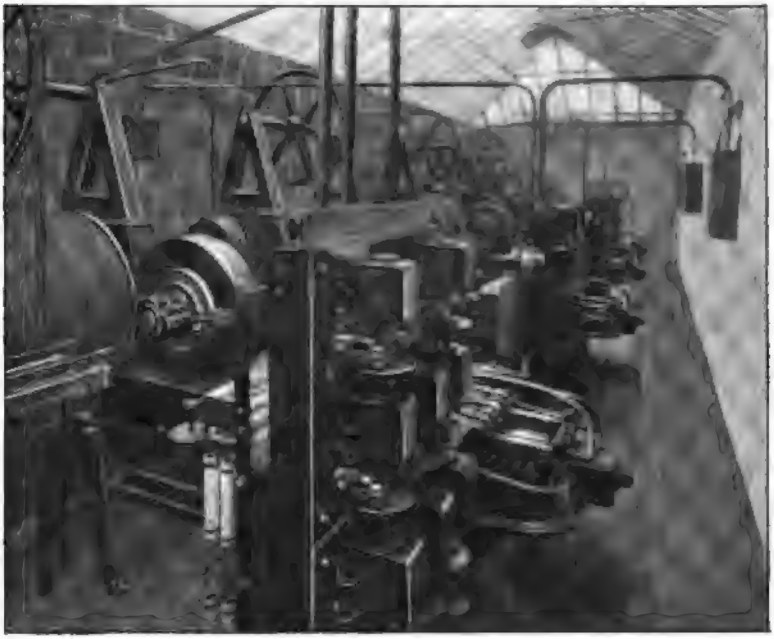


FIG. 2.—A BANK OF ELECTRIC ELEVATORS IN A DEPARTMENT SHOP

ferential rate is entitled to and receives his electricity at a low net rate, and this system has proven more attractive to small power users. The rate having been made such that it was possible for the power producer to become the power consumer at approximately the same or less cost, the other advantages of purchased electric power have given impetus to the movement.

The availability of a source of power which could be used in all, or a portion of, the plant at any hour of the day or night, allowing overtime operation in departments which may get behind, or in the plant as a whole during the rush season, freedom from care and responsibility of maintaining and operating a boiler and engine plant have been potent factors in inducing individual power producers to discard their power-producing equipment and become consumers of purchased power.

Other incidental advantages which have accrued to consumers of purchased power, in the larger cities particularly, are immunity from prosecutions for violation of smoke ordinances, freedom from trouble with coal supply during strikes, and in some cases relief from very costly interruptions of power supply, due to breakdowns in the power plant, which required a shut-down of a week or even a month's duration, to make repairs.

The campaign of solicitation which has been conducted by the central stations during recent years has been no small factor in bringing the advantages of purchased power before the general public and thereby increasing their appreciation of its value to them. The unexampled prosperity of recent years has been attended by an equally great expansion of the use of power for all purposes. Nearly all lines of manufacture require power, and the expansion of business necessarily means the expansion of power consumption.

The use of purchased electric power has increased more rapidly than the rate of power consumption

FIG. 3.—A PRINTING AND ENGRAVING PLANT WITH INDIVIDUAL MOTOR DRIVE

as a whole. This has been the result of causes other than the reduced cost and greater conveniences above mentioned, causes peculiar to electric power and to the central station system of supply. The application of the electric motor to individual machines or groups of machines has made a great saving in power requirements, owing to the reduction in the amount of transmission belting and bearing friction which are eliminated by the introduction of the individual drive, the electric transmission being much more efficient than any form of mechanical transmission.

In some large establishments several small steam plants have been replaced by one electric plant, from which power is being transmitted by wire to the various departments and buildings, the load being smaller than the sum of the loads of the plants removed and the power being generated more cheaply. But in other large plants and in the majority of smaller ones, the investment for the new electric plant has been saved by the introduction of purchased power, which has relieved the consumer of the care of power-producing equipment of any sort and has not tied up capital needed elsewhere in the conduct of his business. He has thus been able to procure his power at a smaller expenditure of capital, and, at the same time, to operate his plant at a saving over the old system of belt transmission and small engines.

Nearly all classes of power consumers have been benefited by being able to purchase central station power, but there is one which has been particularly helped, namely, that class whose power consumption is of an intermittent character, being used for such machinery as cranes, hoists, elevators, saws, punches and other machinery which consumes a considerable amount of power for a few seconds at a time, but whose total consumption is relatively small.

The user of this kind of power re-

quires a plant of excessive size to supply the sudden demands of his machinery, and his plant must operate at a small fraction of its capacity most of the time. The efficiency of production is, therefore, very low, and the cost of the power delivered is excessive. With purchased power, on the contrary, the consumption of power is reduced more nearly to that actually used, as the efficiency of motors at small loads is better than that of a steam plant, and most of the losses due to light-load operation in a steam plant are saved.

The machinery illustrated in Figs. 1 and 2 is of the intermittent type. Fig. 1 illustrates a cold-steel beam saw, which consumes a little under 10 H. P. while not sawing, but while sawing a steel beam, consumes from 60 to 80 H. P. The sawing operation lasts from twenty to thirty seconds, and the next cut is not made until after three to five minues have elapsed.

Fig. 2 illustrates a bank of electric elevators in a large retail shop, which is typical of a large class of intermittent power. The operation of elevators by electric power is much less expensive than by any other form of power, and the intermittent demand makes operation from an isolated plant very unsatisfactory in most cases on account of the flickering of the lights. The central station, having a large generating capacity at the service of its consumers, does not feel the variation in load due to the saw or the elevator, and is, therefore, able to supply power to this class of consumers at practically the same rates that it charges for steady power. Indeed, it is found that the presence of a considerable amount of such machinery on a large system has the effect of giving the central station a fairly steady load.

The possibilities of cleanliness and freedom from shafting when the direct-connected individual motor drive is employed is well illustrated in Fig. 3. This is a printing and engraving establishment where the elimination of belting is especially desirable, and also where the electric motor has proven invaluable on account of the facility with which variable speeds may be obtained.

Other instances of machinery which is being supplied by purchased power are in the cases of,—

Blacksmiths and foundries, where a supply of air-blast is very conveniently obtained by means of electric power, as it is not in continuous use, and no power is being wasted while the blast is not needed.

Clothing manufacturing, in which groups of sewing machines, mounted on long tables, are conveniently driven by electric motors, the motors being suitably housed so that there is no possibility of garments being injured by dirt in any way.

Laundries, machine shops, all kinds of metal work, stone-cutting, woodworking, and a variety of other industries, in all of which the advantage of purchasing power instead of producing it in their own plants is appreciated.

The foregoing comments have been made with special reference to the development of the use of purchased power on a retail basis, that is, installations of less than 400 to 500 H. P.

This article would not be complete without some mention of the purchase of power on a wholesale basis. Power supplied on a wholesale basis first came into prominence through the electrical development of the power of Niagara Falls, made available for use in the city of Buffalo and the vicinity in 1895. The central station company of Buffalo and the large manufacturing establishments having power requirements of 500 H. P. or more became purchasers of electric power from the Niagara Falls Power Company, abandoning their power-producing plants. Beginning with an installation of 25,000 H. P. in 1895, the original Niagara plant has been extended and other plants have been added whose aggregate capacity will amount to upward

of 300,000 H. P. if the plans of their promotors are carried out. This power will practically all be sold in wholesale lots to manufacturers who are establishing their plants in the vicinity of Niagara Falls, to central station companies, and to street railways in Toronto, Buffalo, Syracuse, Rochester and other cities within a radius of 150 miles of Niagara Falls.

The low cost of power generated by a waterfall is, of course, the prime reason for this tremendous development. A parallel series of events has occurred in several other places throughout the Western portion of America, where large water powers have been available, and many central stations are purchasing their electric power from the water-power companies, and they, in turn, retail it through their distributing systems.

The wholesale delivery of power has, however, been by no means confined to water-power plants. Large steam plants are furnishing energy to the lighting and traction companies and have sold power in wholesale quantities to each other in many cases. A central station company in Chicago is now supplying current for one of the elevated railways, and for the surface lines in wholesale quantities, these companies having abandoned the use of their steam plants except for a short period each day.

Other consumers, such as some of the large retail shops and newspapers, whose power requirements exceed 1000 H. P., should also be classed as wholesale power consumers.

Several large manufacturing establishments have within the last year found it to their advantage to use purchased power, either in part or entirely in their plants. A number of these have motor installations aggregating between 2000 and 3500 H. P. Indeed, it seems a fair statement that the use of purchased power is yet in a preliminary stage, and it is not saying too much to predict that the expansion of the use of purchased power, both in wholesale and retail quantities, will far exceed in the next five years that of the five years just passed.

SOME PRINCIPLES OF SOUND ENGINEERING

FOR THE INVENTOR

By Thorburn Reid

Mr. Reid's article is, in a measure, supplemental to the one entitled "Exploiting an Invention," printed in the May and June numbers of this magazine. It excellently illuminates the danger points upon which a good invention may come to grief unless guided by good engineering and business sense.—THE EDITOR.

FEW engineers who may have been associated with inventors in the making and developing of their inventions would be willing to concede to them or their methods any of the properties of sound engineering. On the contrary, such engineers are apt to become explosive when the inventor's engineering ability is mentioned.

That inventors are not primarily engineers is doubtless true, but it is a question whether their effectiveness would not be lessened in most cases if methods of sound commercial engineering governed their efforts. There are rare cases of inventors who are also good practical engineers, but these are the exceptions that prove the rule.

It is, however, possible to include the work of invention in the class of engineering by expanding the limits of that class to include it, and by applying to invention the principles by which it ought to be governed, principles which would differentiate its field from that of other branches of engineering, and would limit the activities of the inventor within that field.

The qualities of mind and the methods of thought of the successful inventor are almost diametrically opposed to those needed by the successful commercial engineer. The essence of invention is newness or, as the patent phraseology puts it, "novelty."

The inventor must do something that has not been done before or must do an old thing in a new way; the commercial engineer, as a rule, follows precedent.

When a problem that is outside of his own experience confronts the engineer, he must try to find out how others have successfully solved it and follow their methods. Except in those rare cases where there is no precedent to guide him, or when the precedents are not numerous enough to establish a uniform standard, the sound engineer will try experiments in commercial work only when the conditions absolutely demand them, or where the success of the experiment means a great gain and its failure can be easily remedied.

The inventor risks failure in the hope of achieving a great success; the commercial engineer takes no risk he can avoid, even though there be a possibility that by taking the risk he may greatly benefit his undertaking.

This does not mean that the commercial engineer may not take risks when the conditions demand them, but that his constant aim should be to accomplish the object sought by machinery and methods that have been standardized by long use, or whose efficacy has been proved in his own experience or in that of others. When, as sometimes happens, he is confronted by conditions that are so new or unusual that the employment of new or untried machinery or methods is unavoidable, it becomes necessary for him to proceed with the greatest care and, if he is wise, he will throw the responsibility back on

his employers by informing them of the risk necessarily involved.

The typical inventor has never any doubt of the success of his invention. Failures mean to him but temporary discouragement; he soon forgets them and remembers only his successes. It is perhaps fortunate for the progress of humanity that this is so, for without his enthusiasm, his contempt for obstacles, his sublime confidence and resilience in the face of failures and discouragements, the inventor would never succeed in obtaining the capital necessary to carry out his ideas, and consequently many of the most valuable inventions would probably never have been developed.

The typical inventor is a creature of fancies, imaginative, enthusiastic, a dreamer nearly always. He belongs in the class of artists, poets, and painters. He is impractical, irresponsible, but often lovable. Like others of his class, his temperament is apt to make him irritable, impatient of restraint, control or opposition. The peculiar conditions under which his art must be practiced, combined with his artistic temperament, often produce in him a state of chronic suspicion of the motives and actions of those with whom he is forced to work. He is incapable of understanding the conservative methods of thought of the commercial engineer or business man and places upon himself and his inventions too high an estimate of value. He has no sense of proportion with regard to the value of money, but dreams of millions with lofty assurance when he may not have enough to buy himself food withal, and gives away his last shilling or, it may be, some one else's, with sublime confidence that God will care for his own.

That the inventor, by reason of these qualities, often falls prey to an unscrupulous promoter or business man is an undoubted fact, but it is also true that many who can ill afford the loss of their savings frequently become victims of the inventor's over-confidence, lack of business judgment, and general irresponsibility in money matters. There is a right way of developing inventions, which is seldom the inventor's way, and the right method may properly take its place as a branch of sound engineering.

It has been said, inventions are out of place in commercial engineering. Their development should be considered as a separate undertaking whose sole object is to determine their value, eliminate practical defects and learn by experience the best way to make and apply them, and those who furnish the money for this purpose should understand clearly the risk they run.

Before such an undertaking is entered upon, it should be ascertained what demand there will be for the invention, what it will cost to make it commercially, whether or not there is any other device already on the market which will serve the same purpose as efficiently and as cheaply and what the probable profits will be.

The patent situation should also be carefully looked into with the help of a good patent expert to determine the value and strength of the patent, the possibility of infringement, the steps to be taken to prove priority of invention and for obtaining patents in foreign countries.

Then a careful and liberal estimate should be made of the probable cost of developing the invention and placing it on the market. It is usually disastrous to start into developing an invention without sufficient resources to carry the undertaking through to a successful issue.

When these preliminaries have been satisfactorily arranged, the work of actual development begins. At this point it is essential that the methods of the commercial engineer should replace those of the inventor if the work is to be carried to a successful conclusion at a reasonable cost.

The first step, then, is to make working drawings of the mechanism which is to embody the invention, and it is important that during this

process the principle of following precedent be held to as far as possible. Usually some operations involved in the working of the mechanism will be new and untried. Often a simple experiment by means of an inexpensive model will furnish the information desired, and even if the making of such an experiment involves considerable expense, it is usually better to make it rather than to take the risk of completing the whole machine and finding it a failure because some one of its minor parts does not function properly.

Every detail of the completed machine must be clearly and completely shown in the drawings before any shopwork is begun. The inventor's impatience to see his invention in actual operation will often prompt him to hurry the drawings into the shop, trusting to luck or his inventive ability to work out this or that detail during construction.

Such a course is seldom, if ever, admissible. It is always cheaper to work out details with a pencil on paper than with steel and iron in the shop, and there is never any certainty that the design of some apparently unimportant detail may not affect the design of many, if not all, of the remaining parts of the mechanism.

Most of us have heard of the man with the great invention almost completed and lacking the working-out of one minor detail, and many have learned to their cost that the lack of just this one detail was fatal to the success of the invention. In fact, so often is this true that of all the inventions that might pass successfully through the preliminary stages, only a very small fraction would ever get by the drawing board if the principles of sound engineering were followed at that stage.

The inventor is an idealist and is seldom willing to let well enough alone. As the drawings progress, he sees ways of improving the invention, ways often involving radical changes in the design and the throwing away of most, if not all, of the work already done. If the new design is adopted, it will not be long before he will repeat the procedure and will continue to repeat it, thus frittering away time and money without making any real progress toward the end in view. If the original invention has sufficient value to warrant undertaking its development, it is better to work out its design to completion and thus obtain a comprehensive knowledge of the difficulties to be overcome and of the means of overcoming them rather than to attempt improvements that will almost certainly involve difficulties as great as, if not greater than, those sought to be overcome. "Rather bear the ills we have than fly to others that we know not of."

Again, the inventive mind wants perfection regardless of cost. Sound engineering, on the other hand, nearly always involves a compromise. Cost must be considered at every stage as well as the practical conditions under which the mechanism will be used.

One of the most important, and usually least considered, elements in the operation of any machine is the human element. Somewhere in the operation brains and brawn must be used, and the brain is often of a low order of intelligence, and the brawn clumsy and uncouth. An expression often used among engineers is that the machine should be "fool proof." It is a common mistake of inventors to design delicate and easily deranged machines to be operated by men of little intelligence or with little or no experience in operating machinery of any kind, while the commercial engineer often feels constrained to fall short of perfection in order to meet practical conditions of this character.

The inventor is not interested in the process of developing his invention for practical use, except in so far as the problems arising in this process involve further invention. His pleasure lies in attacking new

problems and devising means of solving them. It requires more effort for them to apply their powers of mind to the tedious details required to make their inventions practical than most of them can be made to exert. Woe betide the man of money who depends on the inventor for this class of service, for he will wear out his soul in the disheartening struggle to get down to practical results.

The inventor, prolific of promises and predictions, will offer him bright and alluring pictures of the wonderful things he is going to do, each picture fading into oblivion, to be followed by another even brighter until in despair of ever attaining definite results the investor either pockets his loss and drops the whole enterprise in disgust, or does what he should have done at the start,—engages an experienced engineer to winnow the wheat from the chaff and prepare for the market the valuable grains that remain.

From all that has been said so far it is not to be inferred either that every inventor possesses all the qualities attributed to the typical inventor or that the inventive genius has not a well-recognized and valuable function in the material advancement of the human race. A few inventors are perfectly capable of developing and perfecting their own inventions without outside assistance. These are men of strength of will and self-control, who curb their genius within the bounds necessary for carrying one project to completion before starting another. But the very necessity for such stern self-restraint is in itself an evidence of the existence in their temperamental make-up of the qualities attributed to the typical inventor which it is necessary for them to repress.

The drawing of the machine having been completed and sent into the shop, the actual work of construction is begun and carried forward to completion. Here, again, as he sees his ideas wrought in material form, the inventor will see room for numerous improvements, ways in which certain things could have been better done; but unless some serious or fatal mistake appears that was overlooked in the drawings, the original plan should be adhered to even at an increased expenditure of time and money, or at the expense of decreased effectiveness or even of partial failure. The machine should be completed and tested as a whole, so as to determine as many of its faults and defects as possible, and at once, rather than to throw away much, if not all, of the work already done in the effort to remedy some minor defect and quite possibly introduce a remedy worse than the disease.

When the machine has been completed, a test invariably reveals defects hitherto unsuspected, no matter how carefully the preliminary work has been done, and only too often it is a flat failure by reason of some fact brought to light by the test, which was entirely unforeseen and without remedy.

If only minor and remediable defects are thus shown, it is wise to remedy them in the existing machine with as little change as possible rather than to immediately begin the construction of a second machine. In a word, it is well to complete one machine that will accomplish the result sought, even though imperfectly and inefficiently, and test that machine thoroughly, so as to discover its efficiency, its capacity, and its limitations. With the knowledge thus gained, the second machine will be far nearer perfection than by trying to remedy piecemeal the defects disclosed during construction only.

When now the invention has been developed into practical, commercial shape, a multitude of engineering and commercial questions arise as to the best methods of manufacturing and marketing the machine, questions to which the answers depend on the capital available, the nature of the market for the invention, the state of the industry, whether split

up into numerous small concerns or dominated by one or more very large ones, or whether a demand already exists or must be created. The list of things to be considered at this stage could be indefinitely extended, but the important principle to be noted is that such questions should not be left to be settled by the inventor, but by a commercial engineer of sound common sense and extended experience, preferably with the assistance of a business man of experience and ability.

From its very nature and by reason of its value in its true field, the inventive mind is unfitted to rightly decide such practical details, and working them out is usually such drudgery to the inventor that he will not give them the attention they must receive if errors and extravagances are to be avoided.

The true inventor can no more help inventing than a moth can help flying into the flame. He will seek to change methods representing the crystallized experience of many decades, with perfect confidence in his conclusions, although his experience with the methods in question and his knowledge of the history of their development may be practically nil. If, therefore, he is placed in charge of the manufacture of his machines for the market, he will seek to overturn existing shop methods, thus creating confusion, reduced efficiency and increased cost, and will be continually seeing new ways of improving his invention, as he thinks, most of which will be found impractical or detrimental, and all of which will involve delay and confusion that he can, only with great difficulty, be persuaded to consider of any importance.

System and fixed routine are the very breath of life in a commercial machine shop, essential to the efficient and economical progress of manufacture; but these essentials are foreign to the inventive mind.

From this stage onward, in fact, the inventor's activities should be confined mainly to suggestions to be adopted or not, as the commercial engineer may deem advisable, or to the making of new inventions. Any new inventions that he may make, however, should be developed and tested in precisely the same way as the original one before they are placed on the market. It is suicidal to send them out to the customers before they have been tested to determine whether or not they will work properly and to eliminate defects. On no account should customers have such experiments tried upon them, as such a course is likely to lead to refusal of payments or damage suits, as well as loss of customers and of reputation.

The inventor's activities should also not be allowed to get in the way of commercial work, and clog manufacture. Whatever shop work is required for models, experiments, etc., should be considered as subsidiary to the commercial work, and be ordered so as to derange the regular routine of manufacture as little as possible. It must be kept in mind that the making of profits or dividends is now of prime importance, while the new invention can wait; and often the opportunity thus afforded the inventor for deliberation and sober second thought will reveal to him defects to be eliminated or of such a character that they may render the invention entirely valueless.

Most of what has been said above applies to the typical average inventor, with whom the engineer or investor most frequently comes into contact. The great inventive genius, while usually possessing the qualities ascribed to the typical inventor in a highly intensified form, will sometimes combine with these other qualities which are quite as valuable in placing him at his high eminence as those already mentioned.

The genius of this class often has what seems to the ordinary plodding engineer a marvellous, almost uncanny, ability to grasp compre-

hensively the action and reaction of a complicated piece of machinery, to predict the results of certain adjustments or changes, or to know beforehand and plan for all the conditions and requirements that must be met. This is, doubtless, due to his possession of a vivid and highly cultivated visual imagination that enables him to make a picture complete in every detail, and hold it with all its details clear and distinct in his mind's eye while the mechanism thus visualized performs its functions.

Occasionally an inventor may combine most of these qualities with sound business judgment or executive ability and knowledge of men, but such a combination is rare indeed, and the man who possesses it need scarcely set a bound to his ambition.

However, rules and principles are not to be used to fetter genius. The genius is a law unto himself, and will usually succeed in overriding and setting at naught the laws framed for his procedure by other men. The principles outlined in this article apply only to the average man of his class, and even then good judgment must be used in their application. No principles can be framed that will apply to all the circumstances that may be met with, and particular conditions may require bold treatment; but in the main these principles are partly the result of personal experience and partly of the combined experience and judgment of many others, and departure from them is a step to be taken only after careful consideration.

What has been said so far applies mainly to the development and application of an invention after it has been made and patented. There is little profit in attempting to lay down any general rules for, or describe the methods employed by, inventors in the process of inventing itself. Usually they do not know themselves how they arrive at an invention, and, in any case, their methods are instinctive, and, to a large extent, sub-conscious. Inventing is not a science, a profession, or a trade, but an art. The inventor is born, not made, and study and application can no more make into a successful inventor one who lacks the inventor's temperament than they can make a successful musician out of the man who lacks an ear for music, or a painter out of one who is colour-blind. As has been said, the true inventor cannot help inventing; it is part and parcel of his nature, and must find expression.

There is usually a time in the career of the young engineer when he gets the inventor's bee in his bonnet, and unless he has the divine spark of genius, it may go hard with him unless he quickly realizes his limitations. He is apt to cease to be of much value to his employer while the attack is upon him, and is even likely to become a nuisance to his associates and superiors by forcing upon their attention inventions in which they are not interested or whose defects it becomes necessary for them to point out.

Such attacks are often superinduced by a contemplation of the large rewards that sometimes come to inventors. They would, perhaps, not be so eager to try their 'prentice hands if they knew that where one inventor succeeds and gets his reward, a hundred fail and are forgotten; that when the invention has been made, even if it have great value, a long and weary road lies between the inventor and his goal. Money, much money, must be found with which to patent it, develop it, and place it on the market. Other inventions may supersede or have anticipated it, some feature of his invention may infringe some patent already in existence and its value be thus destroyed, some powerful corporation may steal it and rob him of his reward, or may wear him out with expensive patent litigation instituted for that purpose alone.

At its best, invention is but a form

of speculation; at its worst, a gamble. However, if the game must be played, some of the principles of sound engineering may be applied to it.

The inventor should know thoroughly the history of the art to which his invention belongs. The essence of invention is novelty, and unless he knows what others have done he cannot know that his invention has not been anticipated and thus rendered valueless. This information is usually to be obtained only by the tedious drudgery of delving into the files of the patent office and of the technical journals, although in a few branches of industry text-books can be found that give a fairly comprehensive presentation of the history of the art.

He should know by personal observation and experience the present state of the art to which his invention pertains. Even a genius cannot expect, after a few hours' study of an art of which he previously knew little or nothing, to make a valuable advance in it when many other men, some of them probably equally as able as he, may have spent years of work and study at the same problems. By lacking such personal knowledge he will often be ignorant of some factor of the situation not clearly germane to his problem, but which indirectly affects it in such a manner as to render his efforts entirely abortive.

Another essential element of invention is utility, and strange as may seem the necessity of mentioning an element that seems so obvious, no one who has not had experience with them can imagine how many inventions have been made in which this element is lacking,—often even not considered at all.

He should establish the date of his invention by explaining it as clearly as may be to others who may serve as witnesses if the question of priority should ever arise. It is one of the most curious facts of both invention and science that two men at widely separated points, absolutely unconnected with each other, perhaps each ignorant of the other's existence, have often hit upon the same invention or new fact of science at almost the same time and under circumstances that made it impossible that either could have known of the other's discovery before he hit upon it.

There have been cases where the question of priority of invention has been a matter of days only, almost even of hours. The so-called "rotary field" patents are an interesting case in point. The scientific world has accepted without question the fact that Ferraris first discovered and disclosed the fundamental principle upon which the inventions covered by these patents are based; but simply because his disclosure was not so framed as to constitute legal evidence of priority in a court of law, Tesla was able to secure patents based on this principle which he disclosed some time later than did Ferraris, and these patents have been almost uniformly upheld by the courts.

The broad general principle of what may be called the inventive branch of engineering, then, is that invention is an art that requires in those who would practice it successfully certain rare and valuable qualities of mind which are only occasionally combined with sound commercial engineering or business judgment, and that, therefore, the inventor's activities should be confined to invention only, while the work of developing the inventions and placing them on the market should be delegated to commercial engineers and business men who possess the practical judgment that the inventor nearly always lacks.

It is not forgotten that commercial engineers in the regular course of their work sometimes devise new machines or methods that are patentable and valuable, but such cases are sporadic and more or less accidental, for it is almost invariably the case

that the work of the commercial engineer loses in value and efficiency by just so much as he directs his attention and efforts towards invention. It is, therefore, the part of wisdom for him to confine his attention to the solution of the problems in hand by sound engineering methods and consider inventions as a mere accidental by-product.

RENEWABLE RAIL HEADS

By William H. Booth

WHEN it is considered that a rail is worn out when it has lost about 5 or 6 per cent. of its weight, it becomes obvious that anything that will save even a portion of the rail must be very valuable. Tramway rails suffer more rapid loss than railway rails, because the gradients are steeper, there is a much greater proportion of braking, and the amount of grit that gets upon the rail is much greater. Everything tends to wear. The concealment of the fish plate bolts in the paving also prevents that prompt and periodical screwing up of the nuts that is essential to joint permanence. The rail ends of a tramway may become battered, and a rail may be thus worn out before it has lost even its 5 per cent. allowance of wear.

FIG. 1.—THIS MACHINE IS FOR CUTTING THE FLANGES OF OLD RENEWABLE HEADS

When worn out, the cost of new rails is not the only thing involved, for the old rails cannot be removed except by removing the paving on each side of the rail. The new rails must be laid and properly packed and grouted solidly upon the concrete bed and the paving must then be put back. A considerable move has recently been made in the way of renewable rail heads. The idea of a renewable head is excellent. The difficulty has been to carry it into practice. About the earliest system to come much into vogue was that known as Baker's. This compound rail consisted of short lengths of cast-iron ⊥ girders laid on a concrete foundation. The vertical web of the ⊥ was double, and in the middle deep space contained the vertical flange of the rolled steel **T** head. The vertical web was pierced for cotter wedges which passed through both the steel and the cast iron and

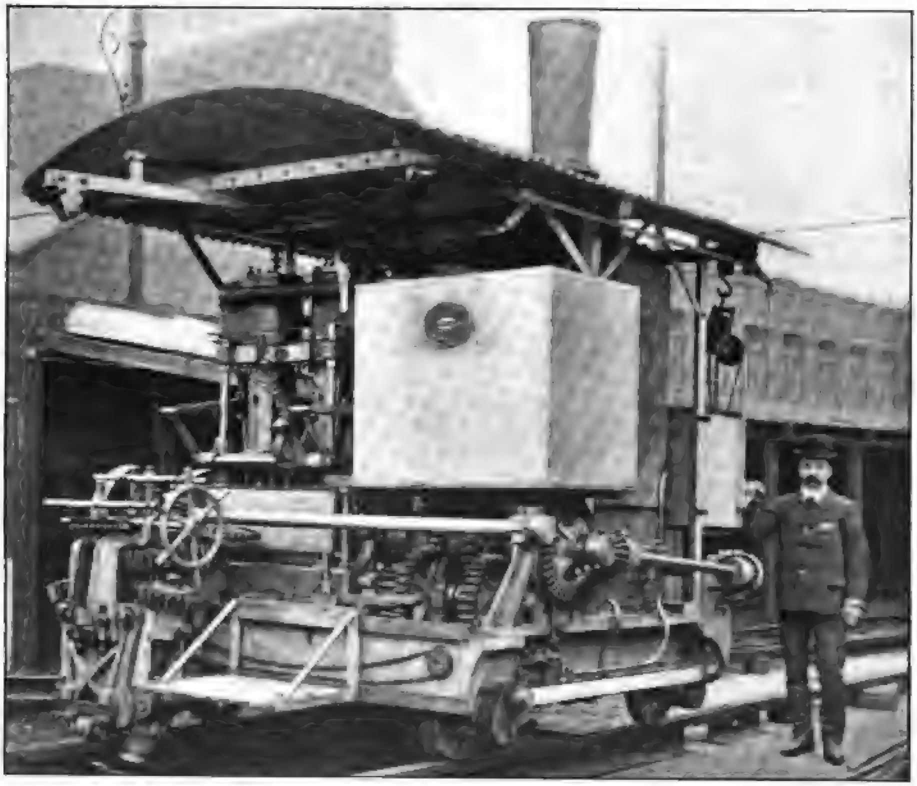


FIG. 2.—ROLLING ON A NEW RAIL HEAD AFTER THE SYSTEM OF THE ROMAPAC TRAMWAY CONSTRUCTION CO., LTD., LEEDS, ENGLAND

held the rail head in place. When worn out, the rail head could be released by removing the wedges or cotters and a new head could be inserted. It could always be arranged for the joint of the head piece to come upon one of the chairs so that joints were always supported. The system was laid down in Manchester, among other places, and was fairly satisfactory.

With the heavier cars of electric lines, however, something different is required. Loose rail heads, held down by bolts with dovetailed heads sunk in the bottom of the rail grooves, have the disadvantage that they do not hold the rail head centrally nor do they hold it continuously. A thin rail head is apt to be curled by the action of the rolling wheels.

In the case of the latest system of renewable head,—the Romapac, here illustrated,—the head of the rail is simply a channel bar with two comparatively thin vertical flanges and a heavy web, the web forming a stout rail head. The permanent rail, to which the top has to be attached, is an ordinary T rail with a small head. The vertical flanges of the renewable head fit closely on either side of the under rail head, and they are then rolled in laterally so as to clip this head tightly by means of pinching rollers carried upon and actuated by a special machine on carrier wheels. (See Fig. 4.)

This machine runs forward upon the evenly applied rail-heads and draws itself forward by the grip of the pinching rollers upon the side flanges to be rolled upon the head

FIG. 3.—A FRONT VIEW OF THE ROLLING-ON MACHINE

of the under rail. When worn out, the renewable head is milled along one lateral flange by a travelling machine, Fig. 1, and the flange is then bent back by a second machine and the head is set free and a fresh new head can at once be rolled on.

The advantages of this system are obvious. In the first place, the under rail remains permanent. Secondly, very little paving has to be removed when cutting away and renewing the head. Thirdly, the head can always break joint with the ends of the supporting rail body, and there can be no joint hammerings, for the top is rigidly held to the solid body of the under rail and cannot hammer under the wheels. The joints, again, of the under rails are bridged by the rail head, which, with its side flanges, possesses considerable rigidity of it-

self and effectively bridges the joint and prevents hammering. A track thus laid is therefore, to all intents, continuous. When worn out, the removal of the head signifies the rejection of a part only of the full weight of steel in a track and the saving thus effected, added to the saving in labour, paving, and concreting, is very great.

In the common system the renewal of a rail means also the renewal of the bonding connections, the cross bonding, and the cross ties which hold the rail to gauge. The total economy is, therefore, very considerable. It does not appear practicable to extend the system to points and to crossings and special work, but the abutting end of such work can be arranged to take the end of the rail head, which thus makes a rigid connection between the straight or ordinary rails and the special work, apart from the connection made by the fish plates. If such renewable heads will actually give the results which they promise to give, they will become the means of introducing the most serious economy in tramway maintenance that has been made since electric traction was introduced.

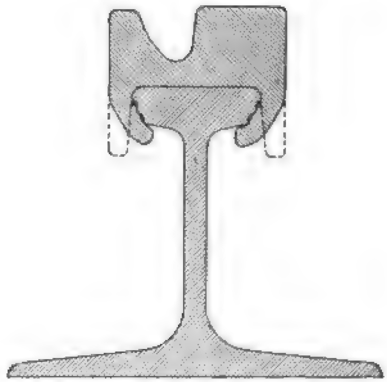


FIG. 4.—THE DOTTED LINES SHOW THE FLANGES OF THE TOP SECTION BEFORE HAVING BEEN ROLLED ON BY THE MACHINE

SPECIALIZATION IN MANUFACTURING

THE MEANS TO SUCCESS IN MODERN INDUSTRY

By Alexander E. Outerbridge, Jr.

Mr. Outerbridge starts with the assumption that nowhere has specialization in manufacturing been so thoroughly developed and so extensively employed as in America. Accordingly, America's remarkable growth is used by him to illustrate the splendid results of such specialization.—The Editor.

SPECIALIZATION is the key note of success in modern methods of economical production, and investigation shows that in all branches of manufacture specialization has been more thoroughly developed in America than elsewhere. This, taken in conjunction with the country's natural resources, i. e., its boundless wealth of raw material, accounts, in large measure, not only for its phenomenal prosperity, as shown in the enormous production and home consumption of manufactured products, but also in the amazing increase in exports of American manufactures especially during the past decade.

For the purpose of showing at a glance the extent of this growth, a few typical figures have been culled from the mass of statistics contained in the volumes of the twelfth census of the United States, selecting industries in which the value of the annual product exceeds one hundred million dollars.

The census of 1900 shows a valuation for iron and steel production exceeding $800,000,000 as compared with $430,000,000 in 1890, and a total valuation of iron and steel industries, including the products of foundries and machine shops, bolts, nuts, rivets, washers, forgings, nails and spikes, doors and shutters, pipe, architectural and ornamental ironwork, etc., of almost $1,800,000,000.

The value of the annual product of the boot and shoe factories exceeded $261,000,000, and the value of cotton goods exceeded $339,000,000. It is said that in 1900 more than three pairs of shoes were made in the factories for every man, woman and child in the United States.

The manufacture of clothing for men reached the astonishing figures of more than $415,000,000, and of women's clothing (factory product only), of more than $159,000,000 in 1900. The latter is a comparatively new industry.

The total annual value of industrial products as shown in the census of 1900 exceeded $13,000,000,000 as compared with less than $9,400,000,000 in 1890,—an increase of 38¾ per cent.

With respect to the value of products of domestic manufacture exported to foreign countries in the decade intervening between the eleventh and twelfth census reports still more remarkable relative gains appear. The value of the exports of iron and steel and manufactures thereof (excluding iron ores) in 1900, is shown to have been $122,000,000 as compared with $25,542,000 in 1890,—an increase of 377.3 per cent. The great bulk of these exports of iron and steel manufactures consisted of articles in which American producers have exhibited special skill.

The value of agricultural implements exported exceeded $16,000,000

according to the census of 1900 as compared with less than $3,900,000 in 1890,—an increase of 327 per cent. The latest reports show that American exports of agricultural machinery in 1905 (not including auxiliary machines used on farms and plantations) reached the sum of $22,124,132. The exports to Argentina alone were $5,733,615 as compared with $805,703 in 1900.

The most remarkable increase in exports is shown in the case of copper and its manufactures (excluding copper ores), viz., $58,000,000 in 1900 as compared with $2,350,000 in 1890. This phenomenal gain was caused by the increased use of copper for all kinds of electrical appliances in which America has taken the lead of the whole world, mainly through the perfection of methods of manufacture. A very recent announcement by the Director of the United States Census Bureau of the result of tabulation of statistics of copper smelting for the calendar year 1905, shows a remarkable increase as compared with 1900, as follows:—

	1905	1900	Per ct. of Inc're
Gross value of products Smelting and refining...	$240,780,216	$165,131,160	45.8

Having thus endeavoured to show by a few statistics the enormous strides that have been made in manufacturing in America, and having claimed at the outset that it is largely due to specialization in manufacturing, it is pertinent to ask specifically what is meant by this term?

Certain fundamental principles characterize American methods of manufacture, such as the employment of special machines to perform specific operations only whereby the output of a factory is enormously increased, minute and systematized sub-division of labour is effected, the costly work of finishing and adjusting is minimized, and the highest development of skill, accuracy and dispatch is acquired. These principles find their most efficient application in large establishments where, in many instances, hundreds or even thousands of repeated operations of the same kind are performed in rotation without material change of adjustment of the machines. As an illustration a case may be cited coming under the writer's observation, where the cost of machining a small bronze casting was reduced from 25 cents per single piece to 2 cents per piece in lots of 500.

Everyone is familiar with the enormous reduction that has been effected in the cost of making of clocks and watches in quantity by machinery as compared with hand work. A watch, guaranteed to keep good time, may now be bought at retail for less than the cost of having an expensive hand-made watch cleaned. In the large factories cheap watches are made in lots of a thousand at a time, and sold for less than $12 per dozen.

Some time ago the writer purchased a neat watch in a hardware store for 75 cents (the regular retail price) and found a printed guarantee of the factory on the inside of the case to repair the watch free of charge, if found not to keep good time and returned to the factory within one year, unless it bore evidence of having been maltreated. This watch has been keeping excellent time for some months without requiring any adjustment of the regulator. The original cost of this watch was less than one-fourth of the interest on the amount paid by the writer thirty years ago for a Swiss watch of fairly good make.

According to the statistics given in the Census Report of 1900, the annual output of watch movements from the factories in the United States was 1,825,769, and its value was $6,036,240, making the average value of the watch movements at the factory only $3.36.

It is undoubtedly true that the high wages paid to skilled labour in America have acted as a powerful stimulus to the invention and perfecting of labour-saving machinery, and the employment of such labour-

saving devices, operated by high-priced, intelligent mechanics, has resulted sometimes in a very much larger output and lower cost of product per man employed than anywhere in the world under old conditions. This accounts for the fact that America is able to compete in the markets of the world in manufactured articles of all kinds, notwithstanding that the wages paid are the highest in the world.

Specialization in manufacture means, in a word, that the manufacturer selects some product for which there is a good demand, or for which a large demand can be created by reducing the cost sufficiently to change its character from that of a luxury of the comparatively few people of wealth to a necessity of the many persons of moderate means. The manufacturer accomplishes these results by devoting his entire capital, energy and ability to the development of the trade, and the betterment of the methods or appliances of manufacture, so reducing the cost as to be in at least partial control of the business.

As an illustration, the manufacture of the metal aluminium may be cited. About twenty-five years ago the writer purchased a small quantity of this, then comparatively rare, metal at a cost of eight dollars a pound. About that time a young chemist, named Castner, devised a process for reducing aluminium from its oxide, using sodium as an intermediary, and showed that he could cut the cost of manufacture in half; a large plant was erected in England at an expense of about a quarter of a million dollars, but before the factory was in full operation an electrolytic method was brought out in America which did away with the use of sodium, and reduced the cost to a mere fraction of that of the Castner process, which latter was promptly discontinued.

The annual report of the United States Geological Survey for 1904, recently completed, shows that this industry dates its beginning from 1883, in which year the production was only 83 pounds. It was not until 1891 that the output reached 100,000 pounds, while the output in 1904 was 8,600,000 pounds. The present quoted price of the metal (over 99 per cent. pure) in ton lots is 35 cents a pound. Nearly all of the output in America comes from one establishment, located at Niagara Falls. With each successive reduction in price, new uses have been found for this metal.

In the foregoing illustrations the writer has endeavoured to show, first, the economy that has been effected in manufacturing where the same machinery and appliances are used, but the quantity is increased, and second, the difference in cost where an entirely new process is used. Innumerable examples of similar kind could be given, but the same principles would prevail in all.

One of the most recent advances noted by the writer is the rapidly growing substitution of machine-moulding for hand-moulding in foundries. As an example of what has been accomplished in this direction, two cases coming under his immediate notice, may be cited. Two green sand moulds, made from different patterns, which formerly cost $1.06 each when made by hand, now cost 11 cents, and 20 cents each made on moulding machines; the cores for these moulds formerly cost, made by hand, 50 cents and 25 cents each; they now cost 11 cents and 3½ cents each made by machines. By hand one skilled moulder could make three of the moulds per day from either pattern. By machine one man,—an unskilled labourer,—makes 48 moulds from one pattern and 21 moulds from the other. In machine moulding the cost here given includes the wages of the machine operator, one helper and one crane operator, while in the former case the cost includes the moulder only.

It is stated that when Edison first made the small incandescent electric

lamps, consisting of a carbon filament fixed by platinum wires in a pear-shaped glass bulb from which the air had been exhausted, the cost was $3 each; now many million similar lamps of better quality are made every year and sold at less than 20 cents each.

There are, at times, dangers of overproduction in this modern system of specialization; nevertheless, it seems to be evident that the secret of success in manufacturing to-day lies largely in concentration of effort in developing the plant to the highest degree so that a superior product may be turned out at a minimum cost. This implies a complete modern equipment of machinery and modern methods of management.

It may be stated as a general proposition that if a new machine be invented which will, by increasing the output only 10 per cent., reduce the cost an equal amount, it pays to "scrap" the old machine. In many instances new machines have been invented which have reduced the cost of manufacture of a given article over 50 per cent. Some time ago a delegation of foreign workmen visited industrial establishments in America, and on their return home made a report in which they said:—

"The (American) manufacturers are unceasingly replacing old machinery by new types. * * * The rapidity of the machines is astonishing, and the development of specialization in manufacture in the United States seems to border on the marvelous."

They referred especially to improvements in the manufacture of agricultural machinery, and of boots and shoes, in which industries they "did not find a single machine out of date." The latter industry has been greatly specialized; there are separate factories engaged exclusively in making uppers, heels, insoles, linings, stiffenings, tips, clasps, strings, staples and a variety of other articles classed as "boot and shoe findings."

The substitution of machinery for hand labour in all industries has effected a radical change in the relations between capital and labour. Formerly there was a well-grounded belief that the employer objected to paying labour more than a certain fixed sum per day and the most efficient worker believed that it was to his advantage to conserve his efforts under the fear that increased efficiency on his part would result, sooner or later, in a cut in his wage-rate, so that in the future he would be compelled to work harder in order to obtain an equivalent amount of money.

Now, the wage earner tends a machine, the cost of which often represents an outlay of a large sum of money, and the interest on the investment sometimes largely exceeds the amount of his wages. It is, therefore, to the advantage of the employer to offer large inducements to the wage-earner,—in the way of "premium" or "bonus,"— to facilitate the operation of the costly machine, so that a maximum output may be secured. This does not mean necessarily overtaxing the strength of the operative, as strenuous labour on his part is, as a rule, not necessary to effect this result; but simply close attention to details is required in order to avoid waste of minutes in making necessary changes of adjustment of the machine.

An actual instance in point is that of two lathe hands working side by side on duplicate machines on the same class of work. One man is highly efficient and ambitious to earn large wages. The average output of good work from his lathe is twice that which is turned off from the lathe tended by a less skilful and less ambitious man. The actual manual labour performed by the efficient man is little greater than that of the inefficient man, but his wages are more than twice those of his companion, for he is worth more to his employer than are two inefficient lathe hands.

The writer would here submit to

the consideration of his readers a few thoughts on the ethical influences of invention of machinery and of modern methods of manufacture upon the wage-earning class, as many writers on such topics cling to the false notion that modern inventions and methods, while of supreme advantage to capital, are detrimental to labour, displacing many hands and generally lowering the intellectual status of the operative. The writer claims, from daily observation in large establishments, extending over a period of thirty years, in which the greatest changes have taken place, that exactly opposite results have accrued therefrom.

Every new successful machine or invention opens up new avenues of industry, often of vast extent, giving employment of new kind sometimes to hundreds of thousands of wage-earners.

Witness the introduction of electric power in all its innumerable applications, such as the telegraph, telephone, dynamos and motors, etc. Under old conditions of hand labour the lot of the wage-earner was hard and often degrading; he lived, as a rule, in poverty and squalour; the proportion of paupers to the self-sustaining, especially among the old and infirm, was vastly greater than it is to-day, for the average toiler could not then earn more than barely sufficient to support himself and his family during the period of his active life in the humblest manner, and very often, therefore, he became of necessity, a charge upon the community in his declining years. The old reports of the Poor Laws Commissioners, of England, more than sustain these assertions.

The Hon. Caroll D. Wright, formerly United States Commissioner of Labour, than whom there has been no more thorough student and investigator of such problems, says:—"The inevitable ethical result of the application of machinery has been to enable a man to secure a livelihood in less time than of old, and this is grand of itself, for it must be considered that as the time required to earn a living grows shorter, civilization advances, and that any system which requires all his time for the earning of a mere subsistence, must be demoralizing.

"In warm and comfortable clothing, in heating and lighting, and in a thousand ways, invention has brought with it more comfortable conditions, including health and longevity, the average of life being 10 per cent. higher than in olden time. * * * Under the old system,—the domestic system,—which was displaced when machinery came in and the factory system was established, the most demoralizing conditions prevailed. Goldsmith's 'Auburn,' and Crabbe's 'Village' do not reflect the truest conditions under the domestic system."

In conclusion, let us contrast for a moment still further the former status of wage earners with the prevailing social conditions of a similar class to-day. Formerly, compulsory education of children was unknown, and all members of a family were compelled to work from morning till night to provide the barest necessities of living. Twelve to 16 hours of daily labour prevailed at one period, and children of tender years were compelled to contribute their share of work to the common meal. We are told that an adult hand weaver could weave from 42 to 48 yards of common sheeting a week, working 12 to 14 hours a day; a weaver in a modern factory, tending six looms, can turn out 1500 yards a week, working 66 hours.

It is said that there was a time when a linen sheet represented 32 days of hand labour, and later that a spinner could turn off only 8 ounces of No. 10 cloth in 10 hours, or 3 pounds a week; the modern operator of the mule spinning machine can turn out over 3000 pounds in the same time, with far less toil.

Millions of wage earners have shared the advantages of the in-

creased unit of production per man, made possible by modern machinery and modern methods. Under the modern factory system, laws have been passed for the protection of workers. Compulsory education of children is the rule in civilized countries, and the evils of child labour have been lessened and will eventually be eradicated. The hours of labour have been shortened and the means of recreation increased. Indeed, in every way the condition of the wage-earning class has been improved.

It is a trite, but true, saying that we are living in an age of intense mental and physical activity in all industrial affairs. People are still living who witnessed the birth and growth of some of the most marvelous inventions and discoveries in methods of transportation, and of conveying intelligence to distant places; we are to-day observing the birth of even greater wonders, such as wireless telegraphy across the ocean, and other practical applications of Nature's laws.

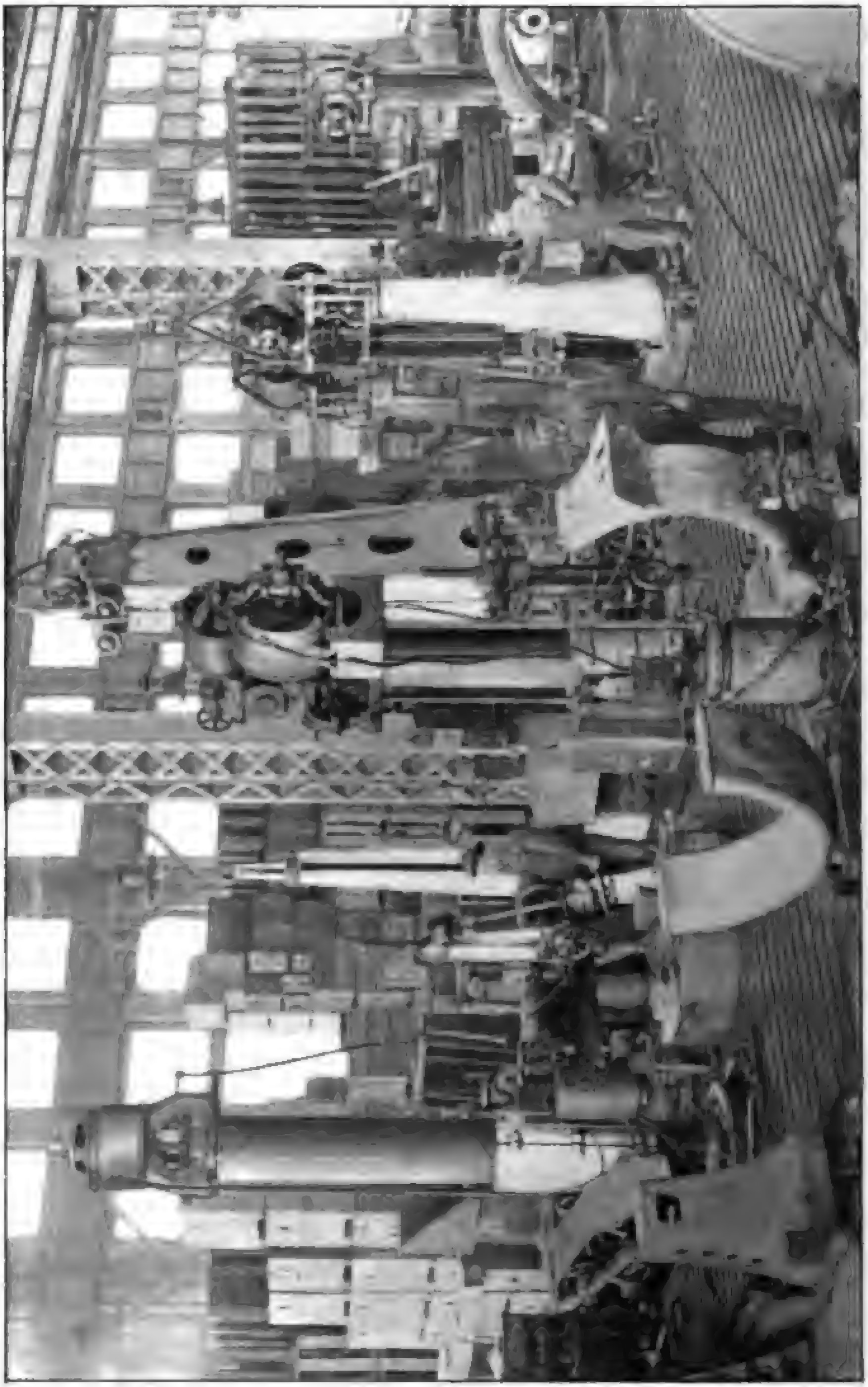
In all these modern creations of the mind of man, America has taken a prominent part, and the few statistics here given may serve to indicate the extent of this contribution to the progress of civilization in the twentieth century in which specialization in manufacturing has proved a powerful lever, more extensively employed in America than elsewhere, so that it may almost be considered as characteristic of American methods. The results prove the correctness of the statement made at the beginning of this paper that specialization is the key note of success in modern methods of economical production.

SOME ECONOMICAL ASPECTS OF THE ELECTRIC DRIVE

By F. M. Feiker

IN these days of close competition, the production of the best article for the least price is the end sought in all manufacturing. For that many a manufacturer spends sleepless nights, thinking out some way by which such and such a process may be cheapened in order that the net selling price per piece may be a trifle less than before. As the cost of labour and raw material advances, the inventor strives harder to evolve an automatic machine which often imitates so well the work of human hands that one has an uncanny sensation while watching its operation,—sure, steady, and ceaseless, with that unfailing certainty of action which we call mechanical precision.

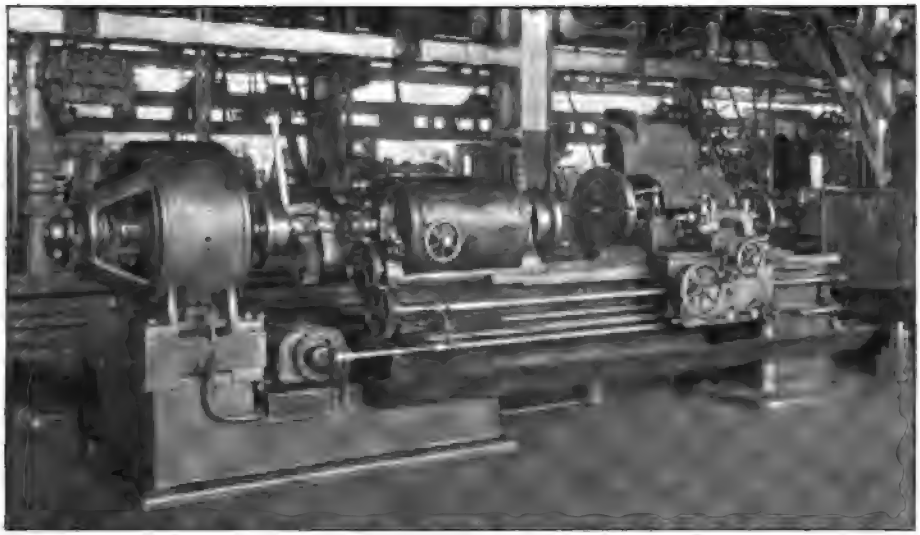
The machines which are thus substituted for much routine work are one of the aids in cheapening production costs. Automatic machinery, however, is not the only relief. Better methods of adapting and applying power to ordinary machine tools aid greatly in the contest between production cost and selling price. It is like the modern contention between heavy guns and armour plate. First a new steel which will resist the impact of any known projectile, then a new explosive or shell which will tear holes through a double thickness of the supposed invulnerable shield. The same is true of the production cost and selling price warfare, with production cost, like armour plate, ever on the defensive.



PORTABLE MOTOR-DRIVEN TOOLS IN THE BULLOCK SHOPS, AT CINCINNATI, OHIO, U. S. A., OF THE ALLIS-CHALMERS COMPANY

FROM A NIGHT PHOTOGRAPH AT THE LYNN, MASS., U. S. A., STEAM TURBINE SHOPS OF THE GENERAL ELECTRIC COMPANY, SHOWING THE ILLUMINATION OBTAINED WITH ELECTRIC ARC LAMPS AND CONCENTRIC DIFFUSERS

MOTOR-DRIVEN TOOLS AT THE WORKS OF THE GENERAL ELECTRIC COMPANY AT SCHENECTADY, NEW YORK. NOTE THE CLEAR HEAD ROOM OBTAINED AS COMPARED WITH THE ILLUSTRATION ON THE OPPOSITE PAGE



A GOOD FORM OF ELECTRICALLY DRIVEN LATHE, THE MOTOR FORMING A RATIONAL PART OF THE TOOL THE MOTOR IS OF WESTINGHOUSE MAKE. THE LATHE WAS BUILT BY THE LODGE & SHIPLEY MACHINE COMPANY, CINCINNATI, OHIO

Within the past few years electricity has entered into this industrial strife as a new factor, coming to the aid of the manufacturer and helping him to reduce his production cost. Electricity is not a sovereign cure-all for manufacturing diseases, but the application of the electric motor to modern machine shop driving is an effective antidote for many troubles. A glance at what this power will accomplish by way of assisting economical production is illuminating.

There are two classes of benefits accruing from the installation of the electric motor-drive in a factory,—those following directly, and a wider, less tangible, but none the less beneficial class of indirect results.

Perhaps the greatest point by virtue of which electricity gives its most efficient aid to the manufacturer is flexibility. In this regard it possesses a direct gain over any other form of power transmission, not only at the machine itself, but in the general layout of the plant. Starting at the engine room, we have a generator,—steam, water or gas-driven,—in itself the most efficient power transformer ever devised. In the larger sizes, 96 per cent. and even 98 per cent. of the power put into it is sent out as useful energy in the form of electricity.

Power in this tractable form is led to the switchboard. This is provided with switches and measuring instruments, and sectionalized, if necessary, so that one portion of the plant may operate independently of all the other portions.

If, in a belt-driven mill, any department has to operate overtime to catch up with production, long lines of heavy main shafting in other departments must run. With the electric drive, on the other hand, only such power is called for as is used and the highest operating efficiency is obtained.

On the switchboard are mounted power-measuring instruments which tell at a glance just how much power a certain room or section of the factory is using, or arranged to indicate the power consumed by a single machine. The importance of this point is easily seen, since the cost of power

for any operation may be known to the fraction of a penny. The exactness by which the amount of coal used in a mechanical operation is calculated is one of the niceties of the electrical system. The manufacturer can reduce his production costs to terms of coal and raw material with the greatest precision.

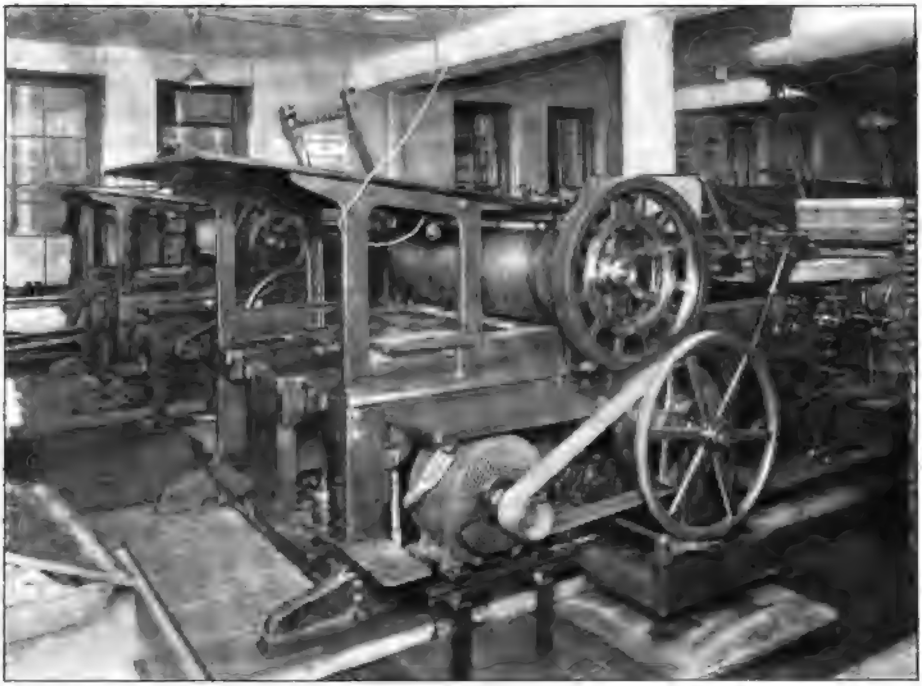
From the distributing switchboard, the power is carried by flexible conductors to the individual motors. Corners are no obstacle; quarter-turn belts that slip off on accidental reversal of engine are done away with; and the power is taken by the shortest, easiest path directly to the individual machine. If a group of small machines, requiring less than two horse-power apiece, is to be driven, it may be best to drive the machines from a short length of light line shafting. In that case a single motor of sufficient horse-power may be adapted for the work. Or it may be that the machinery is of such size as to be most economically driven by individual motors, in which event all the power used is applied directly.

In either case, the manufacturer saves the wastes attendant on the operation of long lines of heavy main shafting and belts. In the average case 50 per cent. of the power generated at the engine is wasted in line shafts and slipping belts. A better result follows only from constant care and attention to bearings, alignment of shafting, etc.,—in other words, by an approach to ideal operating conditions seldom realized in practice.

BELT DRIVING FOR SMALL TOOLS. THE OBSTRUCTION OF OVERHEAD ROOM IS MARKED

At the machine, the economy resulting from the use of electric power makes itself felt in a variety of ways. In some cases the motor, both in its position and action, is the physiological counterpart of the motor nerve centre of the brain, while the operator controlling the machine corresponds to the sensory nerve. This parallel could be carried with entire truth to delicacy of control.

The machine tool with the electric



WESTINGHOUSE MOTORS DRIVING CYLINDER PRINTING PRESSES

drive may be operated faster and more surely than with the old-fashioned belt-drive. Cone pulleys with slipping belts and speed changes with steps of 20 per cent. or 30 per cent. each, have given way to the direct-geared electric motor with a smooth, even, and wide variation in speed, always under the control of the operator. Time is saved by the operation in manipulating the machine. It is under his direct control, with the governing handle in the most convenient position. The tool is always operating at the maximum speed for efficient production, since the control and speed variation are adjustable with a great degree of accuracy.

Control from a distance is another labour-saving feature of the electric drive. The ease and precision of this method is excellently illustrated in the modern rolling mill. Anyone who has watched the operation of the machinery in such a plant appreciates the adaptability of electricity. From the time when the steel fingers descend and grasp from the furnace a white-hot ingot, weighing tons, until the finished bars, rolled to size, cut off the proper length, and, still red, drop from the end of the shears, the entire operation is under the constant control of the man at the levers. In this case electricity not only replaces manual labour, but performs the work quicker, better, and more humanely.

Elimination of belts brings about other results. Suppose a number of machines have been installed with individual motors and the manufacturer discovers that by changing the sequence of operation a saving may be effected; all that is necessary is to move them bodily, without attention to power source, as the electrical connections can be easily made. With a belt-drive, however, the whole room would necessarily have to be rearranged, pulleys and belting changed, as well as line shafting.

Additions can be made without

overloading the line shaft or figuring on pulley speeds, which in many cases necessitate an additional jack shaft and more belts and wasted power in order to drive the machine at the desired speed. Such conditions are not imposed when the flexible electric motor forms the driving unit. With the belting eliminated, the open ceiling space secured is most advantageously used for a travelling crane, serving the rows of machines beneath. Large parts under construction can in this way be moved from one machine to another in the cycle of operations, or heavy work on the machines can be quickly placed in position and lined up for work.

Portable tools form another class of economical machinery made possible by the application of electricity. The introduction of such devices has probably quickened production as much as any one process entering into the construction of large mod-

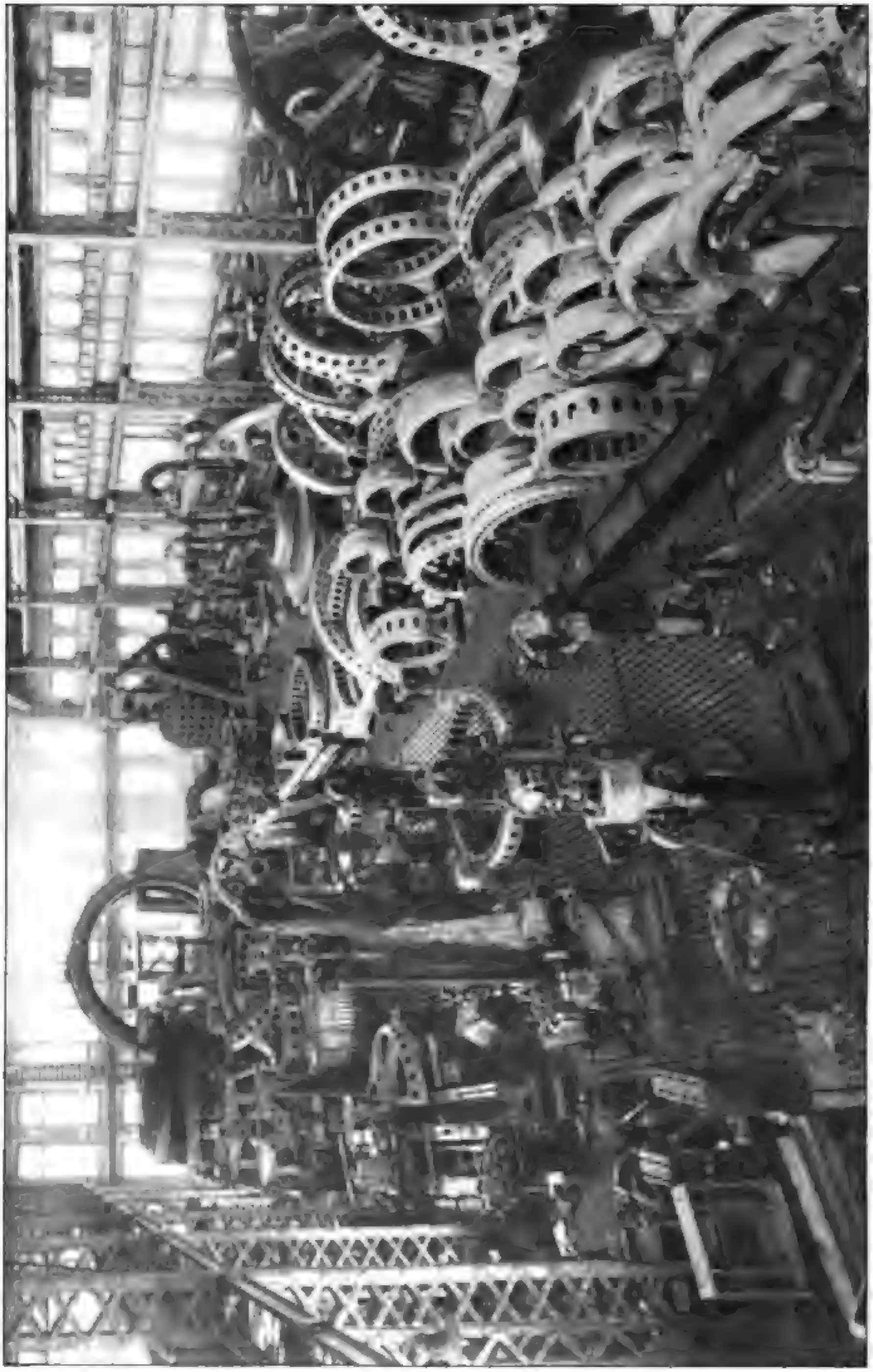
A PORTABLE MOTOR DRIVEN SHOP UNIT, CONSISTING OF A MOTOR AND SWITCHBOARD MOUNTED ON A COMBINATION SHAPING, MILLING, BORING, AND DRILLING MACHINE

AN ELECTRIC MOTOR NERVE CENTER. A SHEAR MADE BY THE CLEVELAND PUNCH & SHEAR WORKS COMPANY, CLEVELAND, OHIO, U. S. A., DRIVEN BY A GENERAL ELECTRIC MOTOR

ern machinery. Formerly the work was brought to the tool, but now the opposite system is widely used. The slotted iron floor of the shop forms an enormous machine base, upon which the work is lined up once for all, and bolted securely. With the crane, the tool with its motor and controlling apparatus, forming a working unit, are picked up and carried to the work. It is a common sight in a modern shop to see portable, electric-driven shapers, drill presses, and boring mills set up around a huge casting, each employed in its respective operation, simultaneously and with the greatest saving in time and labour.

The indirect benefits following the application of the electric motor to machine tool work which tend to decrease production costs are many. Absence of overhead belting means increased safety, cleanliness, light, and quiet. There is no oil to spatter over floor and work, no dust fanned about by whirling belts. Much danger attendant upon working about machinery is done away with, and the liability of accident, due to clothing or parts of the body catching in the machinery, is greatly reduced. Light is a valuable asset in any factory, but particularly where fine work or textile fabrics are produced. Even a naturally ill-lighted room gains materially with clear head space and becomes comparatively bright and open.

Indirectly artificial illumination gains in two ways. Electricity being the motive power, the use of the same energy for light, with all its beneficial results, is a natural se-



INTERIOR OF ONE OF THE ALLIS-CHALMERS COMPANY'S SHOPS AT CINCINNATI, OHIO. THE SLOTTED FLOOR FOR HOLDING DOWN PORTABLE ELECTRICALLY DRIVEN MACHINE TOOLS IS HERE WELL SHOWN

quence. Night work is carried on to the best advantage with this method of illumination, and with the clear head room the light is evenly distributed over the whole area with few shadows. Electricity is the modern light for this purpose. It is easily controlled, clean, and danger from fire is reduced to a minimum. With arc lamps large areas are flooded with clear, brilliant, white light.

In general, then, it is evident that the adoption of electricity not only enables better results to be obtained from the mechanical workers, but tends also toward the betterment of the employee's environment,—a combination best suited to give maximum production with minimum costs.

THE COMPOUND LOCOMOTIVE IN THE TWENTIETH CENTURY

By J. F. Gairns

THE merits and demerits of compounding for locomotives have for about thirty years provided subject-matter for innumerable engineering controversies, some of them heated, and most of them characterized by a good deal of nonsense on both sides; but whereas until the closing years of the nineteenth century it would have been most correct to describe the attitude of the world's locomotive engineers towards compounding as somewhat invidious, though even ten years ago compound locomotives were in use to the number of many thousands, with the commencement of the twentieth century it may be said that the era of the compound locomotive as a recognized feature of locomotive practice really opened.

To-day there is no country of importance where the compound locomotive is not in use to some extent, and they are employed to a considerable extent even in the smaller countries, and those not generally associated with progress. It is true that in some countries, notably Great Britain and Belgium, the compound locomotive is not generally in use, and in the former country it is in considerable disfavour (in both instances there is an interesting selection of experimental engines now on trial), while in Holland and Denmark it is practically unknown; but on the other hand, in France, Switzerland, Italy, Austria, Russia, and Scandinavia a very large proportion of recent locomotives are compounds, and in Germany and North America they are employed in very large numbers.

At one time the compound locomotive was in great evidence in South America and India, but of late years the proportion has somewhat decreased. Rather curiously, however, compound locomotives are in considerable use in countries such as Spain, Portugal, Egypt, China, Roumania and other Balkan States, and Asia Minor. The explanation of this is, that most of these engines are built by German, French, and American firms who are able to introduce their own systems.

When it is remembered that many of these locomotives are designed for the hardest and most important work, it will be realized that it is

both foolish and unwarrantable to argue, as is so often done in Great Britain in particular, that compounding is bad and the compound locomotive a failure. It may be, and probably is, a fact that the compound locomotive is not the miraculous machine that it is sometimes claimed to be, and many of the systems, particularly those of the early dates, possess disadvantageous features; but considered reasonably and with regard to practice, the compound locomotive of to-day is anything but a failure and unsatisfactory.

A notable feature of modern practice in compounding is that whereas in the earlier years the two-cylinder systems (these depended primarily and almost entirely on direct economy for their advantage) were most generally in use, at the present time the four-cylinder systems are most in favour. With these, except in two-crank four-cylinder systems, other advantages result from improved balancing, the division of work over two driving axles, more ready equalization of work between the high-pressure and the low-pressure cylinders (by adjusting valve-gears), and the possibility of providing for very great power, even if somewhat extravagantly, on occasions; and in both cases the work is distributed evenly on either side of the longitudinal centre line of an engine. It is, therefore, probably correct to state that the present satisfaction given by the modern compound locomotive is primarily due to related mechanical advantages, and secondarily to the direct economical advantages of compound working.

It is generally realized that the compound locomotive is to some extent wanting in "elasticity" for much varied work. A simple locomotive can be used in somewhat rough-and-ready fashion, and in the hands of a really capable driver can be made to do wonders with good efficiency. On the other hand, the compound locomotive is designed to depend less on the skill of the driver for its efficiency and more upon its own features; as a result, it requires more delicate handling, and really more skill (of a different character) on the part of the driver and fireman, while, if employed on work considerably varied from that for which it is designed, it is at a more or less serious disadvantage.

It can therefore be stated as fairly correct that the advantage or otherwise of compounding is directly dependent upon whether requirements are comparatively uniform and regular, or diversified, and whether working conditions are principally favourable or unfavourable to the efficiency of the compound locomotive.

On most railways locomotives are more or less frequently required to work unsuitable trains; in Great Britain, so far as the writer can ascertain, this occurs much more generally than in any other country. For example on many British railways it is quite common for the week's work of a first-class locomotive to be somewhat as follows:—

Monday.—A light, very fast express for about 180 miles with perhaps two or three stops one way, and a heavy train, nearly as fast, the other way, with perhaps several more stops.

Tuesday.—Stand pilot in reserve at the terminus, ready to go anywhere or do anything, either in assisting an overloaded train, taking the place of a disabled engine, or running special, time being usually filled in on shunting.

Wednesday.—A heavy fast or semi-fast train one way, and return with a fast or even a slow goods train.

Thursday.—Work a heavy stopping main line train, or one stopping at all important stations, on the outward journey, and return with a light "flyer."

Friday.—Work short-distance express trains, about two double journeys to a day's work.

Saturday.—Work a heavy, fast train out, and return with anything for which it can be used, or perhaps

attached in front of another engine for working home.

This is somewhat exaggerated as regards some British railways, but it is fairly correct for many of them; and when it is remembered that it is nothing unusual for goods engines to work passenger trains, sometimes fast ones, and tank engines to vary their work between fast trains with stops not too far apart, and local goods and shunting work, some explanation at least is provided why the compound locomotive is in general disfavour in Great Britain.

Yet such an explanation can be only partially correct, for Great Britain has not a monopoly of varied duties for locomotives, and therefore other explanations must be adduced to satisfactorily deal with the situation. The most important other explanations in the writer's opinion seem to relate (1) to the official attitude towards compounding; (2) the advantages or disadvantages of the particular systems employed; (3) the relative numbers of compound and simple engines; (4) whether drivers and firemen know how to deal properly with compound locomotives; (5) whether fuel is good or bad, or cheap or dear; and (6) whether it is considered best to employ simple engines capable of doing all that is required with fair average economy, or to employ locomotives which are more economical, but which cost more, at first, are a little more complicated, which require more skill in handling, and which may be handicapped to some extent on some descriptions of work.

As regards the difference in first cost, a good compound locomotive should soon make up for this, but on the score of complication it can be argued that the more parts there are, the greater is the liability of breakdown. Against this, however, is the equally pertinent argument that work can be better distributed over the working parts in the case of the compound locomotive, and, therefore, the liability of each part to breakdown, given equally satisfactory looking-after in both cases, is correspondingly lessened.

Until within the last few years a large number of two-cylinder compound locomotives were provided with automatic starting mechanism whereby live steam could be admitted to the low-pressure cylinder for starting, but as soon as there is pressure in the receiver, compound working commences automatically. In present practice, however, the general tendency is against automatic systems, though they are still employed to some extent. The systems now in use may be classified thus:—

(1) Those having special starting valves or devices for directing the steam passages and for supplying boiler steam at a reduced pressure (by a reducing valve or by wire-drawing) to the low-pressure cylinder; and (2) those in which non-compound working results whenever the valve gear is thrown into full, or nearly full, forward or backward gear.

Some of the modern two-cylinder compound locomotives are remarkable machines, and many of them are of quite recent build, but as a rule they are developments of older designs. Large numbers of older two-cylinder compound locomotives are still in use, but it is also fairly common for such engines to be converted to non-compound, particularly in Great Britain, the British Colonies, and some parts of South America.

Four-cylinder compound locomotives may be classified in several divisions, and their general characteristics may be briefly summed up as follows:—

Tandem Systems:—The employment of tandem compounds is very indefinite. They have been experimented with in many countries, but those where they are employed more or less extensively are Russia, Hungary, and the United States. Good work is done by them without question, but tandem systems are not in

general favour on any railways.

Two-Crank Systems Other Than Tandem:—The only system with this characteristic at all in general use is that for so long known as the Vauclain system, and introduced by the well-known Baldwin Works of Philadelphia for many thousands of engines employed in many parts of the world.

This system is peculiar for the fact that a high and a low-pressure cylinder are superposed at each side of the engine, the two piston rods in each case being connected to a single crosshead, and a single large piston valve controlling the steam distribution of each pair of cylinders.

This system has been superseded for the last two or three years by the Vauclain balanced system.

Four-Cylinder Balanced Systems:—These systems are very numerous. In all cases the cylinders are in line and at each side a high-pressure piston is always moving oppositely to a low-pressure piston, the cranks of each pair being 180 degrees apart and those of one pair being at 90 degrees to those of the other pair.

The systems are, however, diversified according to the relative diameters of high and low-pressure cylinders, whether two or four valve gears are employed, whether two or four piston or slide valves are employed, whether all the valve gears are adjusted in fixed relation or the high-pressure gear is adjusted with reference to the low-pressure gear, or both are independently adjustable, and according to the nature of the devices employed for using boiler steam in the low-pressure cylinders.

Four-Cylinder Divided and Balanced Systems:—The only difference between these systems and those just mentioned lies in the fact that two cylinders actuate one axle and the other two actuate another axle, the wheels being coupled.

Articulated Engines:—In these engines the wheels are arranged in independent groups, one group being operated by the high-pressure cylinders, and the other groups by the low-pressure cylinders.

Three - cylinder systems belong both to the days of the past and to the days of the present. The old Webb system has long been superseded and the slightly more recent Swiss system has also been superseded; but the Smith system is now the most essentially British system in use, and the engines designed according to it possesses a high reputation. As a rule the Swiss three-cylinder engines were designed so that the high-pressure cylinder operated one axle and the two low-pressure cylinders operated another axle coupled with it, but the Smith system is generally applied so that all cylinders drive one axle though on the Great Central Railway of England separate axles are driven.

Current Topics

REFERRING to the short article on "Seeing by Electricity," printed elsewhere in this issue, it may not be amiss to remark that the subject of seeing by electricity to a distance is not a new one. Several years ago the knowledge of the interest that would be aroused in scientific circles by the accomplishment of such a wonder suggested to several prominent electrical engineers of a humorous turn of mind, the playing of a practical joke upon some of their colleagues, which was carried out too successfully if anything. The jokers had caused it to be gravely announced that a device for the electrical transmission of sight had been invented, and a day and place were set for an exibition of the wonderful invention, and to this many of the prominent scientific people of London were formally invited. The particulars of the apparatus were not disclosed, but sufficient electrical apparatus and whirring machinery were provided to lend credence to the statements that electricity was a factor in the operation. At the appointed hour, the spectators were led one at a time into a small room where, on peering into a small aperture, the beholder could vaguely see the face of a friend whom he knew to be at the other end of the circuit in a nearby room. The professional standing of the perpetrators of the joke was such that no one questioned the reality of the exhibition at the time. And not until a serious account of the affair had been published in one or more of the leading technical journals, did it become known that the exhibition was a hoax and had consisted of a clever amplification of the well-known method of seeing around corners by properly arranged mirrors in right angular tubes. It will be readily understood that the subsequent comments of the technical journals that had been "taken in" were not at all complimentary to the perpetrators of the joke.

THE publication of Admiral Melville's article on "American Naval Organization and the Personnel Law of 1899" in our July issue gave us special pleasure because this magazine has always taken an active part in matters pertaining to engineering in the navies of Great Britain and America. It was in these pages that the first careful and satisfactory exposition of the then proposed American "Personnel Law"

was printed (in December, 1897), and we shall maintain our interest and our efforts until the question is settled,—and settled right. Progress in the two great Anglo-Saxon countries,—Great Britain and America—is along so nearly the same lines that it was only the occurrence of the expected when Great Britain put in force a personnel scheme in her navy very similar to that in the American navy. Human nature being much the same all the world over, it would have been astonishing if the "fighting engineer" had met with immediate favour in Britain while receiving rather cold comfort in America. In fact, matters are moving in much the same way in both services, and for the same reason,—the intense conservatism of the older executive officers.

AMONG the letters which have been sent to Admiral Melville, commenting on his article in our July issue, is one from a very able and experienced British engineer who has for many years been in close touch with the British navy and knows the whole subject of engineering personnel. Admiral Melville has kindly let us read that letter, and, as some points are of very great interest, we have secured permission to print the extracts which follow:—

"I have just read your article in the July CASSIER'S, and I agree with every word you say. Please accept my congratulations and my thanks as an engineer for having put the case so plainly. What applies to your navy applies equally to ours. For years it has seemed to me that the old system was a degradation and a most undeserved one to our profession. What has filled me with astonishment and shame has been that the profession and science which alone keep every item and function of a modern navy efficient, should have had to fight so hard for recognition—not altogether for the personal satisfaction of the naval engineers themselves—but that the profession itself should have the credit it deserves.

"IT looks as if the authorities responsible for the administration of our navy were fully impressed with the great truth that every working officer should have an engineering training; it is, in fact, embodied in the new scheme of naval training which makes all naval officers engineers first, and then anything they may choose to specialize for afterwards. In a navy which is entirely dependent for its every function on some appliance of an engineering nature, it is essential that the basis of education and training for its working officers should be in engineering science. It appears to have been easy for the former young engineers of your navy to add the executive duties and become proficient deck officers. This is quite what I should have anticipated. That the converse has not worked so well is also not surprising, as I have long believed that an engineer can much more easily take on the relatively simple and mostly pleasant duties of the deck officer than the latter can qualify himself thoroughly as an engineer. Of course, this does not apply to those who are trained from the beginning for the enlarged field of the modern officer. I have no doubt, if we knew the whole story, we should find that much of this disinclination to become engineers has been fostered, rather than otherwise, by distinguished officers of the old school who hated to see the change, and who would like to relegate engineering and all concerned in it to the depths of the engine and boiler rooms, where they would never be seen, and it might be hoped they would never be heard asking for proper recognition of the profession which is one of the most important, if not the most important, in that fighting machine, the modern war vessel.

"I THINK our scheme of naval training should give us very good officers. It may need amendment later to insure sufficient expert knowledge in the various special lines, engineering, gunnery, and torpedoes. The most pressing point just now is that the engineers, who are not yet an integral part of the military branch, though they have been given military titles, should be merged in the executive as was done in your service. You state the reason for this very well in your article where you speak of the large number of men under the command of the chief engineer. As it is now, the engineers have the responsibility, but have not the legal authority to enforce discipline. A rather curious state of affairs may arise in the near future due to the fact that the young officers of the new plan are full executives, and, as such, have the right of command over the so-called civil branches of the navy. In securing their practical engineering experience at sea, these young officers must, of necessity, be under the control and direction of the older engineers, and yet legally have the right to command them. Such a situation is absurd and could never have developed, but for the prejudices and antipathy of the old-school officers to everything of an engineering nature. As you put it very clearly, the present change has come from the inside, but if it is not worked out properly by the service, it will be made right from outside—that is by the force of public opinion.

"It is, perhaps, expecting too much from human nature to hope that the old type of admiral, as represented by many who received their training when engineering was in its infancy, and who have little or no knowledge of the needs of a modern navy, and little or no sympathy with the just aspirations of the engineering profession, would willingly concede to the new element a position which they themselves look upon as a sort of divine right. But, nevertheless, it is a pitiable and also an iniquitous situation that the real brain and workers of the navy should have to depend upon a semi-obsolete type of individual for the recognition which alone can make the efficiency of the service certain by granting a proper position and a proper scope for the exercise of its functions to the naval engineering profession, which nowadays embraces the whole navy."

AMONG the smaller savings in powei plant operation which are possible at all times, one or two may be mentioned as illustrating the simple ways in which waste can be cut down. In gas-engine plants the sensible heat of the exhaust gases is frequently thrown away. If hot water can be utilized in the plant—and in producer plants a small steam boiler is often employed for water-gas generation—a considerable part of this waste heat can be recovered. It is not a difficult matter to attach a feed-water heater to the gas-engine exhaust pipe, passing the water from the cooling jackets of the engine through the heater on its way to the boiler or other utilizing agency. Water which has been used to cool electric transformers has been utilized in the same general way. In one case the water consumption of the plant was reduced 50 per cent. by this course.

From Other Points of View

The Cost of Armour Plate

From "The London Times" Engineering Supplement.

THE cost of armour plating on a modern battleship approaches one-third of the total amount of the vessel. A vessel of the King Edward class costs about one and one-third millions, exclusive of armament, and Sir William White stated, in his lectures on "Modern Warships," that the armour cost about $2,000,000. According to the best information available, the average cost of that armour must have been about $500 per ton, while the thickness of the plates varied from 12 inches down to 3 inches or 4 inches. It is interesting to compare these approximate costs with those for the armour recently contracted for by the United States Navy Department, to be used in the battleships "Michigan" and "North Carolina." The total weight of armour per ship is about 3500 tons, the thickness of plates varying from about 14 inches to 5 inches or 6 inches. The Midvale Company offered to supply this armour at $345 per ton (average), the Carnegie Company at $370, and the Bethlehem Company at $380. It has been arranged to give the Midvale Company the order for one ship, and to divide the order for the other ship between the Bethlehem and Carnegie companies. These prices are lower than previous contracts, Midvale having quoted about $400 per ton, and the others $445, including a royalty of $25 per ton for the use of Krupp's patents. The latter statement throws an interesting light on the amounts which must be paid by the British Admiralty for the use of the Krupp patents, which, by the way, represent processes largely based on researches in which the late Sir William Roberts Austin and other of our metallurgical chemists took a leading part. According to the Navy Estimates, we are to spend about one and one-half millions for the current financial year on armour for ships now building; therefore the use of Krupp's patents, on the foregoing scale, probably involves a payment of over $375,000 in royalties.

The Midvale Company have no license from Krupp's concessionaires, but they have devised a process of manufacture that complies with the official tests; the other two companies use the Krupp processes, just as British manufacturers do. From the British point of view the important fact is that, if the preceding figures are correct, we are paying for armour about $150 per ton—roughly 40 per cent.—more than is being paid in the United States for armour of equal

quality. On a King Edward type of vessel this involves an increased expenditure of from $500,000 to $600,000.

Naturally the inquiry arises why armour should be more costly in Great Britain than it is in the United States. Five first-class firms undertake the manufacture here. Their united output is said to be equal to the production of 40,000 to 50,000 tons of armour per annum. This far exceeds present demands, and doubtless represents a huge capital expenditure not at present fully productive. It is only fair that firms which have shown such enterprise in a special branch of manufacture should have their reward; but looking to the dividends declared in recent years and to the prices paid by the Admiralty as compared with American prices since the Senate inquiry, their enterprise and expenditure have doubtless obtained the reward they deserved. A point has been reached, however, if the foregoing statements are correct, where British armour-plate makers ought to imitate American competitors, and lower their prices. In the United States serious consideration was given some years ago to the establishment of a government armour factory. Even now the idea finds favour in some quarters, although the action of Midvale has made it less urgent, and the trust is being fought by a private company instead of by a State establishment. Whether a trust exists here or not may be disputed. What is obvious, however, is that prices are kept at a high standard, and that practical uniformity of quotation exists among the five firms.

Blasting in Large Cities

By R. W. Raymond in "The Engineering and Mining Journal."

RECENT numerous instances of damage done to persons and property by blasting warrant a more vigilant supervision, not only of the handling of explosives, but also of the methods of excavation involving their use. So far as danger to human life is concerned, it may be sufficient to secure care and competency on the part of those in charge; but with regard to the perpetual nuisance of noise, and the peril in which buildings and foundations are involved, something more should be, and easily can be done, namely, the unnecessary excessive use of explosives should be prevented. The public now submits to the shocks and dangers of heavy blasts, under the impression that these evils are inevitable. But it is perfectly practicable to make excavations and drive tunnels through rock without such catastrophic performances. In tunneling, for instance, deep holes are usually bored at the face, and heavy charges of explosives are fired in them, with great loss of useful effect, due to the disadvantageous direction of the holes. If a vertical cut were made in the center of the face, small holes on both sides, parallel to the cut, would give with light charges a full theoretical effect, "throwing" toward the center-cut, and wasting neither energy nor noise in pure, useless mischief. The thing has been done. Manufacturers of rock drills are ready to furnish machines which will make the center-cut; and the process, skillfully directed and manipulated, need not be more expensive in the aggregate than the present orgy of misdirected power. Even if the direct cost were a little higher, it would be more than compensated by the immunity from expensive accidents.

If I am correctly informed, this obvious improvement, while it has shown itself to be both practicable and capable of reasonably economical application, has encountered a passive resistance, shown in lack of loyal co-operation, on the part of both contractors and workmen. Engineers do not like to quarrel with contractors over points not definitely fixed by specifications; contractors do

not like to quarrel with labour unions; and labour unions fight, on general principles, all novelties or economies which do not actually increase wages. So there we are; nothing will move all parties but a legal requirement.

Oil and Boilers

From "The Engineer," London

THE Scotch boiler is very far from being superseded. In good hands it has been modified sufficiently to keep step with the latest developments in marine-engine construction. It can carry pressures of as much as 220 pounds, which is quite enough for even quadruple-expansion engines. When fitted, as on most modern lines, on Howden's system, the coolest possible stokehold is secured, radiation from the ashpits being entirely and from the boiler fronts almost altogether prevented. In the matter of repairs and economy it has proven to be so satisfactory that none of the great ocean shipping companies has seen its way to substituting some other form of generator for it. There is, however, a weak place, and that is the adverse effect which a comparatively small quantity of oil has on the furnaces. It is a commonplace of marine engineering that an almost imperceptible coating of oil on the furnace crowns will cause them to overheat and come down,—the reason why has not been conclusively settled. So far as is known, the oil prevents contact between the water and the metal; and absolute "wetting" of the metal is essential to the transmission of heat rapidly and regularly. An excellent illustration of this is supplied by soldering with a "bit." If the surface to be soldered is not clean, the melted metal will not "wet" it, and the surface remains cold; the heat of the bit is not transmitted to it. If the surface has been cleaned by a suitable flux, as, for example, resin, the heat of the "bit" is freely imparted to the tin plate through the melted solder, and union is effected at once. The essence of success in transmission of heat is good contact. Oil prevents it, and overheating takes place. The action of oil is, perhaps,—but this is not certain,—intensified by the presence of lime, oxide of iron, and magnesia, and such like, always found in a boiler. We may add here that sometimes analysis fails to detect oil in the thin deposit on a collapsed furnace crown. This fact is no evidence that the oil was not there, the over-heating vaporizing the oil, and driving it away.

So well is the nature of the risk incurred now understood that oil is hardly ever put into a cylinder. The impermeator has gone to the scrap heap long ago. Although not put in, oil gets in nevertheless. It is not possible to keep piston-rods in order and cool without lubrication. The rods are swabbed from time to time. It is an interesting fact that if steam in motion gets access to oil, it will take it up in much the same way that wind will draw up water. The steam in the cylinder takes the oil off the rod and distributes it through the engine, whence it proceeds with the exhaust steam to the condenser and hot well, from which it is conveyed to the boiler unless stopped on the road. The stopping apparatus is a filter. There are many filters available. For the most part they act as strainers, the oil passing through toweling or sponge, by which it is caught, or supposed to be caught. The process is much better in theory than in fact. A marine engine of only 1000 horsepower will use at least 1500 gallons of water per hour. A modern liner of moderate size will use 15,000 gallons per hour. The efficient extraction of oil from quantities so large cannot be effected without comparatively big filtering surfaces, and the cloths must even then be frequently changed. But this is not the worst of the matter. Many oils good in other respects emulsify with

water under the churning action of the pumps. Now, unfortunately, no means exist of filtering out emulsified oil from water. Emulsification consists in the breaking up of the oil into globules so tiny that they can scarcely be seen under a microscope. They will pass freely through any practicable filter, and finally settle on the steel plates in the boiler, apparently taking furnace crowns for choice. So far, the only way out of the trouble lies in using oils which will not readily emulsify with water. Mr. Morison, of Newcastle-on-Tyne, an eminent authority, in the course of an excellent paper on boiler furnaces, read last year before the North-East Coast Institution of Engineers and Shipbuilders, said:—"It is not the very high-grade mineral oils which give serious trouble in boilers, but cheap, low-grade oils, and particularly the oils used in lubricating the auxiliary engines and deck machinery. These oils, emulsifying with the feed-water, cannot be filtered out, unless the water be first chemically treated; so in ordinary practice they are discharged into the boiler, and there become a source of inefficiency and danger. A cylinder oil for marine engines should be of a known brand, preferably obtained direct from a known manufacturer, and the feed-water should be filtered."

There is another side to this question. When a furnace is overheated it will come down. But what does overheating mean? The word is very vague. Let us suppose, however, that it means a dull red heat. We can picture a furnace so made and of such materials that it would not undergo permanent distortion, much less collapse or breakup, even under a heavy pressure. There is reason to believe that the very overheating would volatilize the oil and break off by expansion any lime on the plates. They would be cleaned automatically, and contact would gradually be restored between the plate and the water, and the plate would cool down and no harm be done. Furthermore, it is plain that some kinds of furnace will be dangerously overheated sooner than others. Thus, we might have a plain furnace which would not be very stiff to begin with, and being equally overheated throughout, would easily come down, while a corrugated furnace would be originally stiff, and, in addition, the overheated portions would consist of rings at the bottom of the corrugations, while the tops, being less liable to hold deposit and further away from the hot flame, would act as strengthening rings and hold up the crowns. This is a condition which has not received all the attention it deserves, though it has not been overlooked. There are many degrees of overheating, and it is indisputable that some kinds of furnace will easily bear up under temperatures which are fatal to others.

But besides shape, there is yet another element which has, so far, received no consideration whatever in the construction of marine boilers. A few experiments have been made to test the tensile strength of steel when heated to various temperatures. These have been intended rather for academic than practical engineering purposes, because, it has been pointed out, it is not supposed that highly-heated metal shall ever be subject to stress. The argument does not hold good of boilers. The shells and stays are never raised to a temperature at which they sensibly lose tensile strength, which may be taken at or about 650 degrees F., while that of 200-pound steam is only 380 degrees F.; yet in a boiler furnace the metal is in compression, not tension, and it is very probable that some steels will endure greater compression stresses when heated than will others. Tool steels, for example, will go on cutting even when red-hot, and we can imagine a flue made of high-speed tool steel which might be heated to redness without collapsing. Of course, we do not

suppose that tool steel furnaces can be made, but between tool steel and 28 or 30-ton steel there is a very wide gap, and it may yet be found possible, when once attention is directed to the subject, to produce a steel which, with other good qualities, would possess useful endurance when overheated. Vanadium steel may, perhaps, one of these days, help in this direction. In any case, we think that a full discussion of the behaviour of various steels when heated and under pressure would be useful and interesting. The field of research in this direction is open. That it has not been more worked is mainly due, first, to the belief that little practical advantage would be gained from an inquiry of this kind; and, secondly, from the assumption that the relations between compression and extension are independent of temperature, so that if the tensile strength of a given specimen was known at any given temperature, then its compression strength would be the same. We venture to think that there is not sufficient justification to be found for the rigorous application of either assumption.

Caisson Disease

From "The Evening Post," New York.

RECENT autopsies performed upon human beings killed by caisson disease indicate that the "bends" is caused by air bubbles in the blood, as those bubbles have been found in the heart, blood vessels, and various tissues and organs. Air bubbles may seem very harmless and it may be asked how they are capable of producing such profound disturbances and often death.

The realization of the serious consequences of air in the circulating blood is as old as Galen, and the danger of allowing air to enter certain veins in the course of surgical operations is guarded against by modern surgeons. If by any chance air as a bubble—that is, in contrast to absorbed or dissolved air—is in the circulating blood stream, it acts like a foreign body. The bubble may pass along for a distance, but at some point it will block the circulation of the blood by obstructing a small artery. Should the air bubble lodge in a vessel of the brain through which the blood passes to nourish some important center, as that which controls respiration, then the brain center would at once cease to function. The individual stops breathing and death ensues. The same is true of an air embolus in the heart. But if the circulation to centers that are not vital is impeded, the other symptoms of the disease are manifested, pains in the limbs and joints and various degrees of paralysis.

In the less severe forms of "bends," complete recovery of health is not unusual, because in the course of a little time the air is reabsorbed into the tissue fluids, and those parts which have suffered as a result of starvation in having the blood stream cut off from them are again restored to normal. Only in the case of the nervous system, where regeneration of injured tissue is especially difficult, do permanent injuries result.

If the man who has been in a caisson for several hours under a pressure of two or more atmospheres passes quickly through the decompression lock—so quickly that the air is not held in solution in the blood, but escapes in bubbles in the tissues—this free air causes, if not death, a train of severe and dangerous symptoms. Physicians have been somewhat slow in accepting the explanation of "bends," probably because the facts seem more tangible to a physicist than to one trained to medicine, and also because the observation of cases in the hospital has revealed little in explanation of the disease and nothing as to means of treatment. In fact, "bends" is a condition which need almost never occur.

Leonard Hill and Macleod, two physiologists of the London Hos-

pital, have repeatedly placed monkeys in a small caisson and subjected them to a pressure of eight atmospheres (117.6 pounds per square inch) without any apparent injury to the animals. These investigators, however, allowed two hours for decompression from this high pressure, which is much more than is ordinarily used in any engineering construction. It is the belief at present that at least fifteen minutes for each atmosphere of pressure should be taken in order to be within the bounds of safety, but whether this precaution will ever be rigidly observed is questionable; and it would be safe to say that the men themselves, as much as any construction company, would object to a period of a half hour spent in a decompression lock, when there is a possibility that no harm would come if only five minutes were allowed for the operation.

Line and Station Protection Against High Potentials

G. E. Palmer, Before the Association of Electric Lighting Engineers of New England

ALMOST any line can be protected against high potentials if sufficient insulation and enough protective devices are installed; but it is, after all, more feasible to try to protect the weak spots in a system than to attempt to insulate or protect it all on the same scale of investment. The majority of so-called static breakdowns in cables are due to defects which follow short-circuiting. The lightning arrester is merely a weak point in the system purposely made weak, and it should in all cases permit line discharges to continue without going out of service or without permitting arcs to form. Zinc, antimony, cadmium, bismuth and mercury are ideal metals for use as electrodes in lightning arresters, for their vapour does not perceptibly decrease the resistance of the gap. The ideal construction should allow equal opportunities at all points for the discharge of high potentials.

A very significant phenomenon was noted in a telephone circuit which Mr. Palmer had installed. The circuit was about 100 miles long and the work in hand was the rebuilding of an old line. It was found that when new, clean insulators were used, the line was very noisy and almost too poor for service. The insulators of the old line were put back, dirty from their former service, and the line at once became one of the best in the whole exchange. The distributed leakage took care of the static discharges without the least trouble.

Mr. Palmer suggested the construction of a special insulator which would offer a high resistance path to earth, constituting a "crack" in the electrical system. The idea would be to dip the insulator into a metallic solution before glazing it, mounting it in service upon iron pins with a common metallic ground connection. The metallic film would not act as a conductor in the ordinary sense, for its resistance might be as high as 50,000 ohms, but it would be able to dissipate abnormal discharges without punctures.

Trouble with Moist Air from an Air Compressor

From "The Engineer's Review."

AIR compressors, as most engineers know who handle them, sometimes cause a good deal of trouble. The plant that I have charge of has been running about two years, and among a lot of first-class apparatus a new compressor was installed, of the compound type, having cylinders 18 inches on the low side and 12 inches on the high side with a 12-inch stroke, belt-driven.

When I started this compressor everything ran all right, but the air was very moist, sometimes getting so

bad that it could not be used on the air hoist in the foundry or on the pneumatic drills in the machine shop, and it was up to the engineer to furnish dry air. The receiving tank would sometimes fill up to one-quarter of its capacity with water.

One Sunday I took off the heads and found that the high-pressure cylinder was full of water, while the low-pressure cylinder was dry. I then examined the cooling chamber which is located between the low and high-pressure cylinders, and found that full of water also. Then I began to see light.

The trouble was caused by the drain pipe from the cooling chamber being connected into the main drain pipe in the engine room. This main drain pipe received the water from all the pumps, condensers and engine drips in the plant. The compressor was provided with a governor which was placed on the air intake pipe. When the ball on this governor is down, the compressor takes air and discharges it until the desired pressure is obtained. Then the ball rises, the intake valve closes and the compressor runs under a high vacuum.

My trouble was that every time the compressor ran under a vacuum, when the valve on the drain pipe on the cooling chamber was open, it drew all the water that was in the drain pipe into the compressor, and from there it found its way into the receiving tank and caused trouble.

I disconnected this pipe from the main drain pipe and the air has since been perfectly dry, excepting in rainy or real cold weather, when it may get a little moist, but not enough to cause any great amount of trouble.

HENRY LATHAM DOHERTY

A BIOGRAPHICAL SKETCH

By John Craig Hammond

THE man who invents and creates, the man who improves on old methods,—a man who is a leader is the man worth while.

To be a leader, to put away old methods and follow some untried path is to bring down a certain amount of adverse criticism. If the man can not weather the fault-finding until his method is demonstrated to be a practical one, he will never make much headway.

Henry L. Doherty is the type of a man who is a leader. He is a man who refuses to accept any set rule for life until he has tested that rule and found he can not improve upon it. He wants the new way, the undiscovered way of reaching an end. He will follow it if, after due deliberation, he makes up his mind that it is practical. He is the type of man who thinks ahead. Because men who have made a success of life in the past followed such and such a rule, it is not enough for Mr. Doherty that he should follow it. Maybe there is a better way; if there is, he wants to find it. Like all men who have made any success of their natural talent, he has the solid foundation for building on the right kind of rules.

He closely follows the rules of life of honesty and hard work. But with all his tremendous duties he is like other folks of flesh and bone. He can laugh, he can play, he smokes,—he likes the society of friends.

Mr. Doherty is one of the younger generation of men to invade Wall

street, but he is not like the accepted type of Wall street man. He is not a speculator on the market. He is a speculator to this extent,—he speculates on his ways of doing business, his experience and ideas, and he has yet to report a failure.

In the towering hive of humanity at No. 60 Wall street, New York, Mr. Doherty has a suite of offices that take up half of the fourteenth floor. There it is that he directs his investments in the gas and electrical field, surrounded by an organization of engineers, accountants, and attorneys that he has been building up for years. In more than a dozen cities he has men who are keeping constantly in touch with the progress of the public utility corporation business,—experimenting, investigating, carrying out his suggestions and ideas.

A year ago it was impractical to approach Mr. Doherty with a request for his photograph. His name in cold type would cause him to shudder with fear. And still he numbers newspaper and magazine writers among his best friends. In fact, among the forty odd clubs of which he is a member, three are press clubs.

"Why not let me write a story of your life?" a newspaper friend said once upon a time.

"Wait until I accomplish something," was the reply.

"But you have accomplished something. You have grown from a boy to manhood, self-educated, self-made. You became a gas engineer, an electric engineer. You are president of gas and electric companies, you own companies, you are vice-president and consulting engineer of the American Light and Traction Company,—you are head of the firm of Henry L. Doherty & Company, bankers; you are a Wall street magnate—"

"Speaking of opals," broke in Mr. Doherty, "I have an extra odd one that I have just added to my collection of stones. It is yours, my dear fellow, if you will please forget what I have done and tell me what I have not done. That's of more importance."

And there the effort of getting the story of the success of Henry L. Doherty ended for the time.

"If I had not become interested in the gas and electric business, I think I would have made a newspaper man," Mr. Doherty said recently. "I liked the business—I like the newspaper men. They represent to me one of the highest types of men we have—that is, if they always follow the rule they should,—do the best they can. Like some engineers, they may cheat themselves at times. We marvel at the progress of electricity—I marvel at the great advancement made in the world of letters."

Mr. Doherty started his career in the gas world at Columbus, Ohio, under the tutelage of Emerson McMillin—a man who, Mr. Doherty claims, is the best gas man in the country. There may be better gas engineers, better electrical engineers than Mr. Doherty, but there is no better combined gas and electrical engineer.

In association work of gas and electric companies he has been one of the pioneers in advancing the cause. The Doherty rate for charging for gas and electricity and the Doherty new business methods have been up for discussion during recent years. The Doherty gas calorimeter, furnace combustion regulator, tar extractor, gas purifier, gas air compressor, and on to a score and one other inventions came from the fertile brain of Mr. Doherty.

While still a young man, Mr. Doherty has spent more than twenty-five years in the gas and electric business. He is never satisfied with what he does or has done; he is constantly striving to improve and to advance. For a year past, in addition to giving his time to managing and operating nearly a score of plants and gas works, including one street railway and water company, he has been turning his attention to the

buying of new properties. He has a following of Western bankers and men of money who take his word without question,

Recently Mr. Doherty acquired a new property. The purchase price was over $1,000,000. The entire money for securing this property was subscribed by friends.

"I have a good property in sight. Will take a million. How much stock do you want?" was the question sent out by Mr. Doherty.

One man answered: "What and where is the property? Count on me for $50,000 if O. K."

"Can't tell you about property now. My word goes with it."

"Give me $100,000 worth if your word goes along," came back the answer.

That true little incident indicates the blind confidence his friends and associates have in his ability and judgment.

"When you make a friend, keep him. You can keep him only by being right and fair," is the motto on which Mr. Doherty is doing business.

"The electrical business—it is old to say it—but we are only getting started," said Mr. Doherty. "To-day the best indications that this is true are the constantly growing followers of public utility corporations. Management has become a science in these stations—even as great as service.

We have demonstrated that we must keep in touch with the public, deserve the good will of the public by being fair and giving them the best service at the least possible cost. A central station run on that principle has no reason for failure."

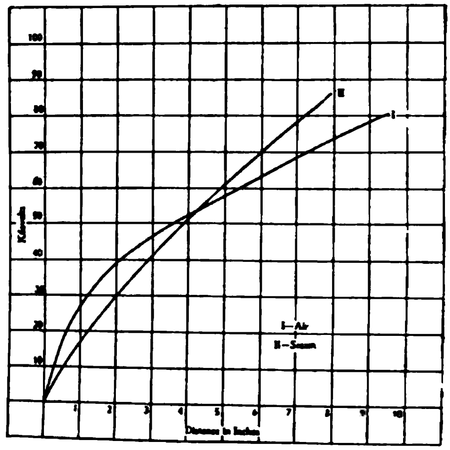
"poisoning" of the platinum was intimately connected with the stopping of its pedesis. Whether Kuzel's finely divided metals should be called colloidal suspensions, gels or hydosols is for the present purpose a side issue. The fact appears to be that he has invented a most ingenious way of converting metals into a fine, smooth paste, in which the particles are so exceedingly small that very fine filaments of paste can be squirted. These filaments are then heated electrically until they practically fuse together.

If this invention works practically, as there is little doubt it does, it opens a very large field, because it puts the inventor in the position of being able to make lamp filaments of any metal he chooses. It is simply a matter of choosing one which has a high melting point, and is otherwise convenient. Of course, the melting points of the very refractory metals are not yet ascertained. It has been known for a long time that tungsten is very infusible; and it was considered an achievement when it was first fused in the electric furnace some fifty years ago. The metal is otherwise so unpromising physically that to make from it a lamp filament is a very remarkable triumph over the apparent obstinacy of inanimate things.

Effect of Smoke on Trolley Wire in Joint Operation

From the "Street Railway Journal"

APROPOS of the general increase in the outcome of the many proposals now under way looking to joint operation of electric cars and steam locomotives over the same tracks, there has been considerable discussion as to whether, if high-voltage trolley wires are placed over the tracks of railroads using steam locomotives, and particularly at such places as in tunnels and under bridges, there might be dielectric discharges from the trolley



GRAPHIC REPRESENTATION OF TESTS TO DETERMINE THE RELATIVE TENDENCIES TO DIELECTRIC DISCHARGES IN ORDINARY AIR AND IN STEAM

to the locomotive and ground, caused by the steam and smoke of passing locomotives acting as conducting mediums. To determine the actual properties of steam and smoke under these conditions and to find out the likelihood of trouble from this source, certain tests have recently been made, and are described by S. M. Kintner in a recent issue of "The Electrical Journal." Mr. Kintner states that in the first test two terminals were placed one above the other and arranged so that the space between them forming the discharge gap could be varied at will. The terminals were ½ inch in diameter with spherical ends, and were so mounted that jets of steam and smoke could be projected around the terminals in a direction parallel to their axis of support.

In the first test a column of steam was projected across the gap between the two terminals. The steam was purposely made very moist by passing it through a long line of pipe, so that it lost a large quantity of heat before arriving at the gap. The results of this test are shown in the curves on the accompanying diagram. In summarizing the results the author points out that the strik-

ing distance, or distance at which current will jump the gap, is greater for a given voltage in air than in smoke for voltages below approximately 55,000, but that at this point the curves cross each other, and it requires a greater voltage to jump a given gap in steam than in dry air. The jumping distance in air, as plotted in this curve, was obtained by measurements taken at the time the curve for steam was determined, the same terminals being used and the points checked several times, so that it seems certain that the values are relatively correct. During the test with steam the terminals were saturated with moisture to such an extent that the water dripped from them freely. No perceptible change was noted, however, when the steam was somewhat drier.

The next test was made to determine the conductivity of smoke and cinders. The terminals were immersed in a dense volume of smoke produced by building an intense fire in a small stove. After a hot bed of coals was obtained some fresh coal, containing considerable dirt, sulphur, etc., was thrown on to the fire to prevent perfect combustion and produce large quantities of very dense black smoke. It was in this case impossible to maintain constant conditions through a sufficient period to obtain a curve, but a number of observations were taken which indicated that the striking or jumping distance through dense smoke was not materially reduced from that of the steam or air in the previous test.

One set of readings was as follows:—

TABLE OF VOLTAGE-STRIKING DISTANCES IN DENSE SMOKE AND STEAM

Voltage	Distance in Inches
14,000	1.375
25,000	2
35,000	3
42,000	3.75

From these tests the conclusion is made that with a reasonable factor of safety, of possibly six or seven, over the dielectric strength of air, no difficulty will be encountered through steam and smoke from locomotives attracting current from an overhead trolley wire.

The Prevention of Engine Wrecks from Cylinder Water

From "The Engineering Record"

MANY serious accidents to engines are caused by water finding its way into the cylinder from the steam pipe when the latter is not properly drained, and even from the boilers themselves when these, for any reason, throw it off in the process of priming. Water is also drawn back into the cylinder in the case of condensing engines through failure of the condensing apparatus. These accidents do not occur without good reason, for when the plant is in operation and all its parts are in proper condition, the chance of trouble from this cause is extremely remote. It is the vigilance of the engine-driver and fireman upon which dependence must be placed for the prevention of injury. Instances of this sort have been often mentioned where engines have been broken down as a result of the introduction of water into the cylinder, and, as everyone who has had experience in the matter knows, the effect is liable to be disastrous. It is not merely a few bolts which break or some minor part which becomes deranged, but some vital piece in the structure is the thing which usually gives way, involving the stoppage of the engine and the work which it drives for days or weeks at a time, until the necessary repairs can be effected.

It seems a pity that accidents which from one cause or another are so liable to occur, and which are attended with such important consequences, cannot in some way be made less disastrous. With so much at stake, designers of engines might bring about some system which should lessen, if not wholly over-

come, the evil results following the introduction of water into the cylinder. The engineer maintains that he cannot supply in his design the brains and vigilance which the engine-driver lacks. He claims that it is one of the exigencies attending the generation of power that a charge of water may get into the cylinder, and when that happens the only thing to do is to accept the consequences, however serious they may be. This, however, is not what the power-plant purchaser requires from engineering. He states the conditions, and what he desires of the engineer is that the iron and brass shall be so put together that the conditions will be met, one of the most important of which is that his plant shall be kept running and turning out regularly the allotted quantity of production.

Considerable improvement has been made of late years, it is true, with a view to providing against injuries of this kind. Cylinders are fitted with relief valves, set at a point slightly above the highest working pressure, and made of considerable size, so as to provide a means for the escape of water if it should accumulate in excessive quantity. They are applied to the sides of the cylinder, one at each end, and with this location it will be seen that they can be made of only limited size. Experience has shown that this plan does not secure a sufficient opening to discharge the large volume which must be taken care of if the water comes over at all.

In the case of single-acting engines, the injury produced by accidental accumulations of water can be greatly lessened by making the cylinder head of such form that when a dangerous pressure is brought to bear upon it, the breaking strength is exceeded, and the central portion of the plate gives way, and allows the water to discharge through an opening, nearly, if not quite, the full size of the bore of the cylinder. Such an arrangement is impracticable on the ordinary double-acting engine, owing to the attachment of the framework of the engine to the opposite end of the cylinder. The same idea, however, might be carried out by providing a secondary cover of a diameter considerably less than that of the cylinder bore, the cover being designed so as to give way by breakage when a dangerous pressure is reached and thus provide a relief opening of much greater size than could be had by the common practice. There may be other methods of accomplishing the same end, but it must be admitted that some better means of meeting emergencies in the running of engines due to water in the cylinder should be provided. There is something incongruous in designing some detail of a cylinder so weak as to invite breakage when the pressure reaches a certain limit. but if this serves as a safety valve and prevents the wrecking of the main structure, it is certainly a wise provision.

Some Export Trade Humbugs

Edward Neville Vose, before the New England Cotton Manufacturers' Association

THE commonest type of export trade humbug is the syndicate agent. It is by no means unusual for a group of manufacturers in closely related lines, or perhaps residing in the same city or belonging to the same club, to form a little syndicate or organization for the purpose of sending a salesman abroad to represent them all jointly. This plan is proper and entirely practicable. The humbug who seizes upon this idea reverses it. Instead of the manufacturers who form this "syndicate" working together and hiring the foreign salesman who seems to them most capable, the agent makes his own arrangements with each manufacturer separately. Instead of confining the syndicate to four or five closely related lines,—such as clocks, watches, silverware, and jewelry,—he calls upon anybody

he thinks he can get and cheerfully undertakes the representation of watches, steam engines, hair restorers and sulky plows, and as many other lines as he can run across. While usually asserting that he intends to have at most only ten firms in his syndicate, the agent often secures that number in a single city and then goes on for more, telling each new victim that his firm is the last one needed to complete the enterprise. As the agent has no intention of so much as attempting to secure business for his clients, it is easy for him to make big promises. It is the folks who intend to keep their word who are hampered by having to keep within the prosaic limits of probability. The thing to do when such syndicate agents come around is simply to put their statements to the test, insist on knowing the name of every firm composing the syndicate, investigate the agent's credentials and antecedents, and, in a word, treat the whole proposition just as you would if it related to domestic trade instead of foreign. There is no hocus-pocus about export trade that prevents the ordinary rules of business and of common sense from being applied to it.

An ingenious variation on the syndicate idea is that of the species of humbug who proposes to sell the manufacturer's goods strictly on a commission basis with a small salary to cover expenses. As the salary is to be deducted from the amount of the first order, and is not due if there are no orders forthcoming, the manufacturer considers himself quite safe in signing this contract, and cases have even been known where men who have been victimized by the syndicate game have been victimized a second time by this clever and apparently innocent scheme. What happens, however, is this. The swindler disappears with his contract in his pocket, and for a year or so no more is heard of him, and he is well-nigh forgotten. Then an order is received from some distant point through his New York representative. The goods are shipped as directed, but instead of a remittance the manufacturer receives a neat little "statement" showing that his account with his forgotten "agent" stands somewhat as follows:—

To twelve months' salary at $50 per month, as per contract	$600
To commission on sale at 10 per cent	60
Total	$660
By merchandise, as per invoice	600
Balance still due	$60

While the cool request for another sixty dollars or so is usually ignored, the manufacturer really has no redress in a case like this. The goods are beyond recovery, and are, of course, sold before this "Statement" is ever rendered, while if the humbug were caught,—which is also difficult, —his "contract" would probably protect him against a criminal charge, and his utter lack of resources renders a civil suit useless. The only way to avoid such expensive experiences is to act toward such propositions as toward syndicate schemes, —rigidly investigate everything, and reject absolutely those that show the slightest ground for suspicion.

The very latest wrinkle in the line of export agent humbuggery was brought to my attention only a few months ago and hailed from Egypt, although I have since learned that a somewhat similar scheme has been tried elsewhere. A firm in Egypt made a contract with an American manufacturer whereby it was granted the exclusive agency of the manufacturer's goods for that country, the contract to run for two or three years unless formally terminated. As no orders were ever received, the American concern decided that its agent had gone out of business or was unable to effect any sales, and allowed some of its products to go to another Egyptian firm. The "exclusive agent" seems to have been waiting for this very thing to happen, for he immediately pounced upon the manufacturer with a suit for 50,000 francs damages for breach of contract. The

case went to the plaintiff by default, and he secured the full amount demanded and costs, together with a court order authorizing him to seize the defendant's goods or property in any part of Egypt. The result of this procedure was not so serious in point of actual loss, since the goods thus seized amounted to only a few hundred dollars in value, but this manufacturer now finds himself barred out of the Egyptian market indefinitely, while his competitors may be getting a firm foothold there. The same scheme in France or Mexico or any large buying market might result in very heavy loss both in confiscated goods and in trade. It is rarely worth while to contest such cases, since local courts will almost invariably favour the plaintiff, and foreign lawyers are usually troublesome and expensive. It is extremely difficult to prevent a few packages of one's goods from getting into a country tied up by such an exclusive contract, even when the utmost care is taken to do so, since merchandise often travels by roundabout channels.

A most pestiferous colony of humbugs once established itself at Amsterdam and preyed upon American manufacturers for a number of years until finally suppressed by the Chamber of Commerce of that city and the post office. These rascals, who turned out to be few in number, fixed up letter-heads representing a great number of fictitious firms, and wrote around to manufacturers whose names they secured from advertisements in export papers, and even from the consuls.

To each one they represented that they were about to open "spacious warerooms," and solicited a few "samples" of his products, to be duly installed therein in a place of honour. The fountain pen manufacturer was to send half a dozen or so of his best gold-mounted fountain pens, the carriage maker one or two carriages, and so on. No article was too large and none too small to merit a place in this magnificent emporium. Many manufacturers were victimized, particularly those making specialties of no very great value, such as washing machines, kitchen utensils, etc. It was simply a case of petty larceny. No orders ever came, and when investigation was set on foot,—too late, as usual,—it was found that no wareroom existed, the firm having only a letter box, which had some time since been given up. This type of humbug still continues to flourish here and there, though no longer at Amsterdam. Not long ago I was shown twenty letters in French from a firm in Egypt addressed to as many different American manufacturers and asking for samples of all degrees of costliness, from a patent scalp brush to a stationary engine. It was simply the Amsterdam humbug in a new locality. The only way to avoid such pitfalls is either to refuse samples to all foreign buyers unless paid for in advance, or take such steps to ascertain the responsibility of the parties asking for them as ordinary prudence would seem to dictate.

PHOTO BY STEIN, MILWAUKEE

HENRY LATHAM DOHERTY

SEE PAGE 566

CASSIER'S MAGAZINE

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ENGINEERING IN THE PIKE'S PEAK REGION

By John Birkinbine

THE one hundred and four thousand square miles of plains and mountains, sombre canons, and snow-clad peaks within the boundaries of the State of Colorado, include numerous scenic attractions and many impressive engineering achievements which have been so well advertised by thousands of tourists, or by railway literature, that we hardly appreciate that the State, on July 4 of this year, celebrated its thirtieth anniversary of American Statehood.

Five years ago, President Roosevelt, in an address at Colorado Springs, said:—"With the exception of the admission to Statehood of California, no other event emphasized in such dramatic fashion the full meaning of the growth of our country as did the incoming of Colorado. * * * The westward spread of our people across this continent has been so rapid, and so great has been their success in taming the rugged wilderness, turning the gray desert into green fertility, and filling the waste and lonely places with the eager, thronging, crowding life of our industrial civilization, that we have begun to accept it all as a part of the order of nature. * * *

"There was scant room for the coward and the weakling in the ranks

THE RACK RAILWAY UP PIKE'S PEAK

of the adventurous frontiersmen—the pioneer settlers who first broke up the wild prairie soil, who first hewed their way into the primeval forest, who guided their white-topped wagons across endless leagues of Indian-haunted desolation, and explored every remote mountain chain, in the restless quest for the metal wealth.

"Behind them came the men who completed the work they had roughly begun; who drove the great railroad systems over plain and desert and mountain pass; who stocked the teeming ranches, and under irrigation saw the bright green of the alfalfa and the yellow of the golden stubble supplant the gray of the sage-brush desert; who have built great populous cities—cities in which every art and science of civilization are carried to the highest point—on tracts which, when the nineteenth century had passed its meridian, were still known only to the grim trappers and hunters and the red lords of the wilderness with whom they waged eternal war."

In the corner of the original Louisiana purchase, defined by the Arkansas River on the south, and the crest of the Rocky Mountains on the west, are many of Colorado's famous natural features, and instances of mining, transportation, and industrial development, descriptions of which would fill many pages,—a development which seems the more remarkable considered in connection with the public recognition of the discovery of Pike's Peak, in 1806, by the centennial celebration at Colorado Springs during the month just passed.

The city of Denver with its 170,000 inhabitants, with water-supply, gas and electric light, sewers, trolley systems and other public utilities, its 75 miles of paved streets, flanked with substantial buildings and comfortable homes and 150 churches; its extensive industries and comprehensive railroad facilities, is a marvel when we recall the fact that it is but half a century since the site of this progressive municipality, this commer-

THE PIKE'S PEAK RAILWAY.—CLIMBING THE GRADE NEAR THE SUMMIT

SNOW OBSTRUCTIONS ALONG THE LINE

cial, industrial and railway center, was recognized as Auraria on Cherry Creek. Then a few crude buildings cared for the limited population and for those who made tedious overland journeys of 500 miles from the banks of the Missouri River,—a journey which is now covered in comfortable cars in a few more hours than the days formerly required by stage coaches with relays of horses.

Pueblo, with its great iron and steel plant, its smelters and its busy population of 40,000, is another surprising evidence of progress, for among its business men, still active, are some who lived and traded in the cluster of adobe huts which received the Spanish name for village, and whose protecting stockade was a welcome refuge for those who traversed the historic Santa Fe trail, watching day after day the white dome of Pike's Peak, which on each

THE RACK RAILWAY UP PIKE'S PEAK. BEFORE REACHING THE SNOW LINE

succeeding morning seemed no nearer than on the previous day.

Colorado Springs, a later settlement, is the mecca for a majority of tourists who visit the Centennial State. The railways offer phenomenal scenic features and easy access to mining centers. Not the least of the attractions are the imposing slopes and snow cap of Pike's Peak, which seems to rise as a barrier to the principal thoroughfares, an impressive mountain, first brought into public notice a century ago, by the report of Lieutenant Zebulon W. Pike, whose name the peak bears, and made famous as an objective point for pioneers and emigrants wearily tramping the seemingly endless plains, in search of precious minerals, or a home in the then unknown "far west," whose slogan was "Pike's Peak or bust."

Florence, with its oil wells producing a thousand barrels daily, its metallurgical works, and the marvelous fruit belt tributary to Florence and its neighbour Canon City, Portland, with its central industry, the rich mineral development of Cripple Creek and Victor, and the coal fields along the Frontal Range, all contribute evidence of progress in the Pike's Peak region.

The vistas obtained from the summit of Pike's Peak, 14,147 feet above sea level, seem unlimited. To the east lie the great plains, seemingly as level as a floor, although there is much rolling ground, at an approximate altitude of 5000 feet, the region of extensive fruit, melon, and beet sugar cultivation, supported by extensive systems of irrigation. Other views give successions of snow-clad mountain ranges, all of which have been prospected for mineral, and encouraged developments, such as Leadville, which has produced $250,000,000 in gold, silver, manganese and iron, and the newer Cripple-Creek-Victor settlement, whose mines are contributing $2,000,000 in gold monthly, and supporting nearly 20,000 people, at elevations ranging from 9000 to 10,000 feet above sea level.

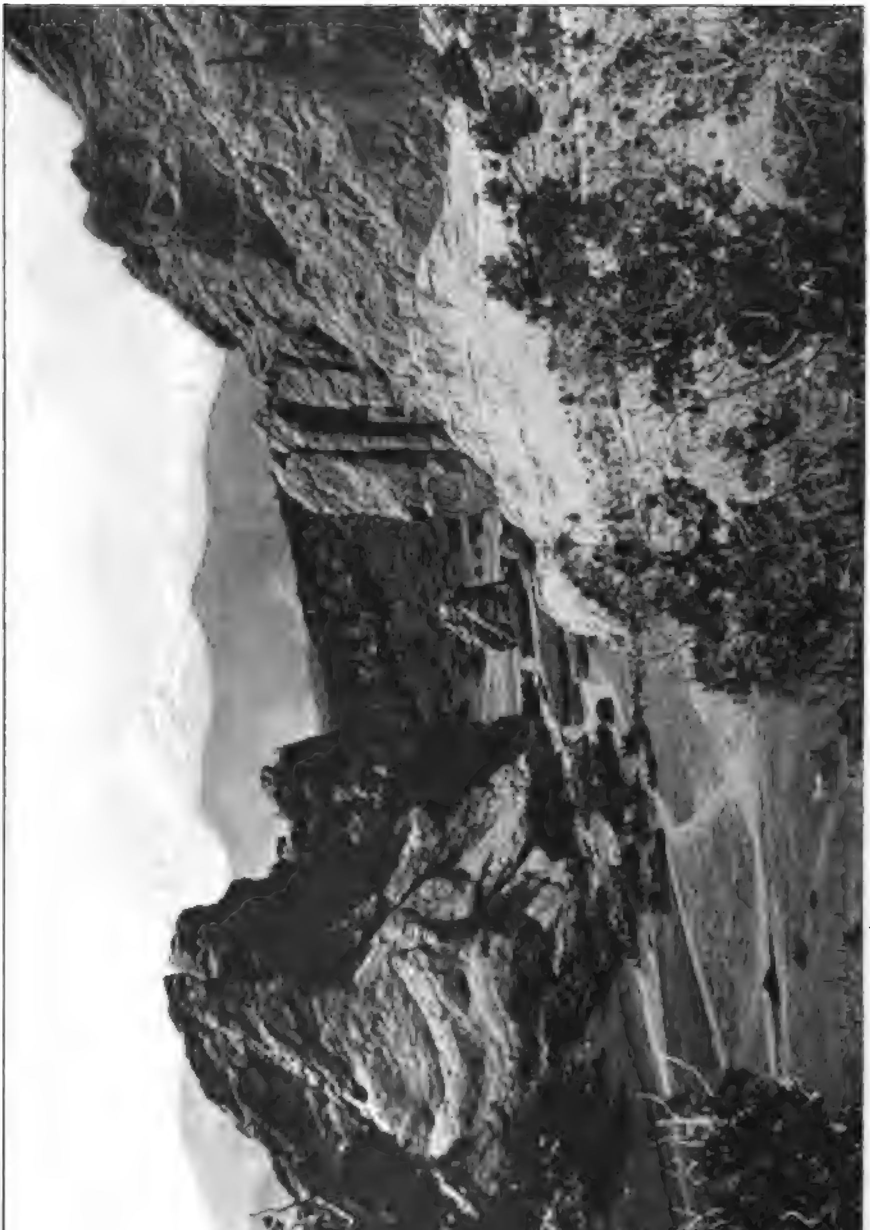
In every gulch or canon, on abrupt slopes of the mountains and far above timber line, are the dump piles of the miners' prospecting shafts and dogholes, many being records of blasted hopes, yet indicative of determination and persistent effort. Standing on this summit, with no sound of the busy world below reaching us, and looking east over the boundless stretch of prairie, Manitou and Colorado Springs appear below as children's toy villages, railroad tracks are as mere pencil marks on a print, and industries at Pueblo, or mines at Cripple Creek are located by columns of smoke; then, viewing the apparently unending mountain peaks, at elevations of from 9000 to 14,000 feet, one feels what small factors of the great world we individually are.

Lieutenant Pike started from St. Louis on July 15, 1806, on his trip to the Rocky Mountains, or Mexican Mountains, as he called them, and reported the country through which he traveled so devoid of sustenance for human beings that it would for all time serve as a barrier in the expansion of the United States. "The wide plains that staggered his imagination on account of their desolation are now dotted with prosperous farms or ranches. The mountains that appealed to him only with their scenic grandeur have been found to be the treasure vaults of nature, then waiting to be opened by the hardy frontiersmen who followed Pike nearly half a century later." The great white mountain that he declared could not be ascended by a human being, is now the objective point of thousands of tourists annually.

Lieutenant Pike was, when twenty-seven years old, chosen to lead the important military expedition on which he discovered the peak. He had previously traced the head-waters of the Mississippi to their source, and this second journey was through the

LIEUT. ZEBULON W. PIKE, WHO DISCOVERED THE PEAK IN 1806

then unexplored territory of Louisiana. He was in command of a squad of private soldiers, a physician, guides, Indians and horses. The condition of the little party was becoming desperate when, on November 15, 1806, the "Mexican Mountains" were sighted from the banks of the Arkansas River in what is now Western Kansas. Pike determined to press on to the "great white peak." On November 27, 1806, when he and two followers climbed to the top of a mountain some 15 miles from the peak, Pike wrote in his diary that the great white mountain seemed to be



GATEWAY TO THE GARDEN OF THE GODS.—PIKE'S PEAK

as high again as the mountain he had climbed, and that it would be impossible for a human being to reach the summit.

After noting the peak, Pike returned to the Arkansas River at a point where Pueblo now is, continuing his journey into the mountains and thence to New Mexico, where he was captured by the Spaniards.

But the purpose of this contribution is to invite attention to some special problems which have been, or are to be solved by engineers in the vicinity of Pike's Peak, and not to discuss Pike's expedition to this corner of the Louisiana purchase, for using the summit of Pike's Peak as a center, a radius of 50 miles will include many industrial and engineering features of phenomenal interest and bold conception.

A century seems a longer interval of time in the newer settled portions of the country than on the eastern sea-board, but even there, buildings 100 years old are so unusual as to attract notice. There is, however, nothing to-day in the vicinity of Pike's Peak which existed when General, then Lieutenant Pike, first visited that locality, except the eternal hills, a few trees, remnants of the forests, and ancient Indian trails, some of which have been developed into roads; in fact there are few buildings extant which Fremont saw in 1843.

Half a century ago the settlements were few and widely separated, but to-day important municipalities, such as Denver, Pueblo, Colorado Springs, Victor, Cripple Creek, Florence, Canon City, Trinidad, Salida, Leadville, etc., are well built, supplied with water, gas, electricity, trolley systems, and other public utilities, while the valleys and plains support innumerable farms and extensive fruit orchards.

The engineer has encircled Pike's Peak with railroads, and on the summit are seen the smoke and steam from the locomotive which has climbed the mountain by the cog road. He has pierced adjacent hills with shafts, drifts, and tunnels, harnessed water-powers, constructed reservoirs and ditches, built metallurgical and other industrial plants, laid out cities, with water, gas, sewer, and electric light systems, constructed trolley roads, etc.

The trains, seen from the summit of the peak, travel on rails made in Colorado; the motive power is developed by coal mined within the State, some of the coal workings being plainly in sight; and the smoke from smelters, reduction works, steel plants, and cement works indicate industrial activity in the vicinity of Pike's Peak. From the United States station on the summit, weather reports and meteorological observations are daily telegraphed, and visitors can communicate with friends in any part of the world.

Some of the roads in the vicinity of Pike's Peak evidence boldness in conception and perfection of construction, giving excellent opportunity to exhibit the skill of the whip, or chauffeur and for the enjoyment of those who travel on wheels or on horseback.

THE RAILROADS

In railroad construction marked ability has been shown, and passengers in turn are charmed by the impressive near views of cliff and canon, the vistas of great plains and extensive mountain ranges, or startled by the succession of deep cuts, high embankments, bridges, tunnels, sharp curves, etc.

Railroad history in the Pike's Peak region dates from 1870, when the Denver & Rio Grande Railway constructed its line from Denver through Colorado Springs to Pueblo, and subsequently from there west and south. The western extension includes the location of the roadbed beside the Arkansas River, through the cleft in the hills, which, in the "Royal Gorge" shows a vertical depth of over 2000 feet, to Salida, from which point branches pass over the Conti-

nental Divide, via Marshall and Tennessee passes, and into the Rio Grande basin over Poncha Pass. Later, the Atchison, Topeka & Santa Fe Railway paralleled the Denver & Rio Grande, climbing the summit at Palmer Lake, at 7237 feet altitude, to Colorado Springs, Pueblo, and La Junta, to connect with its main line to the west.

The Colorado & Southern Railway also constructed a third line, but abandoned much of it and now use the Santa Fe tracks, and the Missouri Pacific Railroad extended its road to Pueblo, to connect with the Rio Grande system. The Chicago, Rock Island & Pacific Railroad also runs its tracks into Colorado Springs and into Denver over the Union Pacific Railroad tracks. In addition two railroads start from Colorado Springs, one, the Colorado Midland, which passes through Manitou, and then, by tunnels, sharp curves up to 16 degrees, and grades reaching 4 per cent., ascends Ute Pass, encircling the north side of Pike's Peak on the South Platte drainage, thence going back to the Arkansas Valley, which it crosses, passing the crest of the continent through the Busk tunnel of Hagerman Pass, altitude 10,944 feet, to Aspen, Glenwood Springs, and Grand Junction. This road has a spur to the Victor, Cripple Creek district.

Another, the Colorado Springs-Cripple Creek District Railroad is a later connection between Colorado Springs and the mining district. It climbs the side of the Cheyenne Mountain, crossing, instead of traversing, the canons, and passes to the south of Pike's Peak. On this road curves and tunnels abound, but the gradient does not exceed 4 per cent., nor do the curves exceed 16 degrees. This road operates the high and low-line trolley systems of Cripple Creek District.

The Cripple Creek region is also reached from the Arkansas River from Florence, by a narrow-gauge branch of the Denver & Rio Grande Railroad,—the Florence and Cripple Creek branch, following a gulch or canon. The railways which encircle Pike's Peak represent two essentially distinct types of construction, two practically following water courses, and gaining height by development when the canon's declivity was too great, the other skirting the mountain side with a succession of grades and curves.

The unique feature in railroad construction in the Pike's Peak district, however, is the Manitou & Pike's Peak Railway, familiarly recognized as the "cog-wheel route," which ascends the mountain from the mouth of Engleman's Glen in Manitou, elevation 6650 feet above sea level, to the summit of the peak, 14,147 feet above the sea. This elevation of 7500 feet is overcome in a distance of less than 9 miles, the road being standard gauge with a double steel rack placed in the center of the track, the teeth meshing into wheels on the locomotive.

The road is mainly for passenger travel, and as it is claimed to be the longest in existence and to reach a higher elevation than any other, the ascent of Pike's Peak by rail has become a feature of tourist travel. In operating the road, the locomotive pushes the car up the slope and descends before it, but the two are not coupled, thus adding a factor of safety in case of derailment, the cars having individual brakes which act upon wheels meshing into the rack.

The average grade of the road approximates 16 per cent., but a maximum of 25 per cent. exists for a considerable distance, and the maximum curvature is 16 degrees. The locomotives weigh about 30 tons each and are of the compound Vauclain type of Baldwin make. The portion of the year in which this road is in service is limited by climatic conditions, but to make the summit accessible, even during the months of active travel, the snow plow, flanger, and rotary must be kept ready for service, and be used a considerable

A DISTANT VIEW OF THE PIKE'S PEAK COMPANY'S POWER HOUSE. THIS VIEW WELL ILLUSTRATES THE CHARACTER OF THE COUNTRY TRAVERSED BY THE PIPE LINES LEADING TO THE SEVERAL POWER STATIONS

time both after and also before these features of railway equipment are used on most of the Western railroads.

In a resumé of the railroad construction in the Pike's Peak region, interesting details of methods of surveying, selection of route, features of grade, curvature, rock cut or tunnel work, embankment, trestle or bridge construction are necessarily omitted, but from the brief statement presented it will be evident that the engineer has solved difficult problems, some of them in a heroic manner, to make accessible the wealth and scenic beauties in the vicinity of Pike's Peak.

This is true not only for the roads in the vicinity of the mountain, but also for those throughout the Rocky Mountain region, as there are many instances where the steel rails traverse deep gulches, span canons, or are laid in notches excavated from the sides of high cliffs, around abrupt promontories, or passing through them in curved and tangent tunnels, some of them of considerable length.

ALONG THE 30-INCH REDWOOD STAVE PIPE LINE OF THE PUEBLO & SUBURBAN TRACTION & LIGHTING COMPANY. SEE PAGE 499

THE POWER HOUSE OF THE PIKE'S PEAK POWER COMPANY

THE ARKANSAS RIVER

The Arkansas River presents interesting and varied features in its course from the Continental Divide at Tennessee, Hagerman, Alpine and Marshall passes, to its confluence with the Mississippi River in Arkansas. The blankets of snow which perennially cover Mounts Massive, Marshall, Herbert, and the collegiate ranges and Sangre de Cristo ranges, form the genesis of the Arkansas River, and the engineer has attempted to equalize some of the run-off by constructing storage reservoirs near the head-waters, and also other reservoirs, 200 miles down the stream on the great plains, their function being to feed hundreds of miles of irrigating ditches which make fruitful large areas of land. The river has an average fall of 1 per cent. in the first 100 miles, when it dashes through the canon of the Royal Gorge, with nearly vertical walls half a mile high.

In addition to liberal utilization for agriculture, enough of the water tributary to the Arkansas River is employed in placer workings to convert the pellucid stream into a muddy river, carrying large quantities of solid matter in suspension, but no serious effort has been made to adapt the volume of flow to producing power.

Most of the minor tributaries of the Arkansas River have reservoirs to store water, and ditch lines to distribute this essential for agricultural and domestic uses.

The snow cap of Pike's Peak is the source of a number of streams, the drainage being mainly to the Arkansas River through Fountain and Beaver creeks. Fountain Creek, which passes through the city of Colorado Springs, does not offer water of a character desirable for household use, but is applied to the irrigating ditches which give life to most of

PART OF A PIPE LINE SUSPENDED OVER ROUGH GROUND. IN THE BACK GROUND A WOODEN-STAVE STAND-PIPE IS SHOWN. SEE PAGE 499

the vegetation in the city and vicinity. It was a branch of this stream, about 30 miles south from Colorado Springs, which engulfed a train on the Denver & Rio Grande Railway in September, 1904, although ordinarily no water is seen in this tributary, and an 18-foot opening is considered ample provision for ordinary freshet conditions. The so-called "cloud-bursts," which occur at irregular intervals along the frontal mountain range, usually prevail over limited areas, but on these the precipitation is enormous. In railroad construction it would therefore become neces-

sary to provide at each arroya crossing for an area of waterway which appears out of all proportion to the normally dry, or nearly dry, stream beds which are crossed by tracks. Unfortunately, few of these "cloudbursts" have occurred where rain gauges were established, or where exact data are obtainable, and the relation of volume of flow and of drainage area is undetermined.

An interesting development in progress between Colorado Springs and Pueblo is the attempt to collect from the underground waters in the Fountain Creek Valley a supply for the city of Pueblo. Clay drain pipes laid across this valley are expected to collect the subterranean flow and divert it into a concrete conduit line 36 inches in diameter, which will connect with a wooden-stave pipe line of the same diameter, for furnishing water by gravity to the busy city of Pueblo.

The presence of subterranean waters in pervious gravelly strata below the sand, and adobe surface cover of the plain slopes, has been the subject of a monograph published by the United States Geological Survey, and enters as an important feature in the litigation by which the State of Kansas seeks to limit the application of the water of the Arkansas River in Colorado to irrigation.

SOME WATER PROBLEMS

Few visitors who enjoy the well-shaded streets and clear water of Colorado Springs are aware that the water supply for this city of 30,000 inhabitants is unique in some features, and an exhibition of commendable public spirit which encouraged the liberal financial outlay, approximating $3,000,000, which the system demanded. Nor do tourists realize that every tree which borders the streets was planted, every building in the city erected, within the past thirty-five years.

Far up the southwesterly slopes of Pike's Peak, close to the perennial snow cap, and partly above timber line, are a series of lakes or ponds, some natural and some artificial, from which Colorado Springs, Victor, and Cripple Creek obtain their water supply. The contest for water has been carried on, even at these elevations, with such persistency that armed guards have at times been stationed to prevent pilfering the precious liquid. Others, claiming to be lawful owners, have invoked the law and submitted guards to imprisonment, and turned the waters into the claimed rightful channels, while prolonged legal battles have been fought to maintain or protect water-rights.

With a rainfall approximating 15 inches per annum, a considerable portion of which falls as snow and remains upon mountain ranges, and with part of the balance deposited in severe storms, more or less local, the conservation and utilization of water is a question of serious moment, and Colorado was the pioneer in making legislative provisions for the control of its water supplies. By the laws now operative the Governor appoints a State engineer, and irrigation division engineers for each of such prominent drainage basins as those of the Platte River, the Arkansas River, the Rio Grande River, and others. In addition about sixty water commissioners are appointed by the Governor, each of these being in charge of a defined water district. The State engineer has absolute supervision of all water resources of the State of Colorado and their utilization. Through his deputies he measures the allotment of all water-rights and passes upon the construction of all dams or reservoirs.

Early in the settlement of the Rocky Mountain section, the necessity of artificial irrigation became apparent, and owing to the depleted condition of the streams during most of the year, the right to take water to irrigate a specific section was acknowledged, and was at first a part of the deeds. As the number of settlers increased and the demands for water became greater, applications

exceeded the normal capacity of most of the streams, and water-rights have been granted for greater volumes than pass down their channels, even in time of ordinary freshets, or when the rapidly melting snows from the mountains send down water in great quantities.

Colorado early established the right of priority; that is, the parties who made application for and were granted water, have prior claims than others whose applications are filed and allotments made at later dates, and these water-rights have become a matter of purchase and sale, their values being based largely upon the date of appropriation.

The adjudication of water-rights is, therefore, in many cases quite difficult, and efforts to settle conflicting claims by resort to force were to be expected in cases of emergency which arose before the disputes could be heard by the State officials. Such rival claims for certain water from Beaver Creek led to contentions between Colorado Springs and Cripple Creek.

An outline of the principal supply for Colorado Springs will illustrate some of the difficulties which have been overcome by the municipality and its engineers in obtaining an adequate supply of desirable water. Beaver Creek drains a large portion of the south and west slopes of Pike's Peak, and on one of its tributaries a reservoir was constructed at an elevation of 12,100 feet above sea level. From this the water is led to a second reservoir on another tributary at an elevation of 11,700 feet. From this second reservoir the water is conveyed by a tunnel 6500 feet long into another water-shed, and to a third reservoir at an elevation of 11,280 feet. This tunnel, 5 x 7 feet, has an average grade of 0.5 per cent. in addition to a drop of 6 feet, reported to be due to errors in level when the headings from the two entries met. A second tunnel, half a mile long, conveys water from another stream. After following an open channel for a mile, the water enters a steel pipe, 18 inches in diameter, which leads to a hydro-electric power station operated by the Cripple Creek Short Line Railway Company.

The plant has a Pelton waterwheel under 704 feet head, driving a 300-KW., three-phase, alternating-current generator, yielding current at 6000 volts and 60 cycles per second. The current is transmitted to the Cameron power house of the Colorado Springs & Cripple Creek Railway, distant 12 miles, and is there transformed by two 150-KW., rotary transformers into direct current at 550 volts, and the direct current, working in parallel with that of the steam-engine driven generators at that power house, supplies current to the electric railways between Victor and Cripple Creek.

From the hydro-electric plant the water passes into Lake Morrain, a reservoir with a capacity of 492,000,000 gallons, at an elevation of 10,246 feet, constructed by connecting portions of a natural morrain by an artificial embankment.

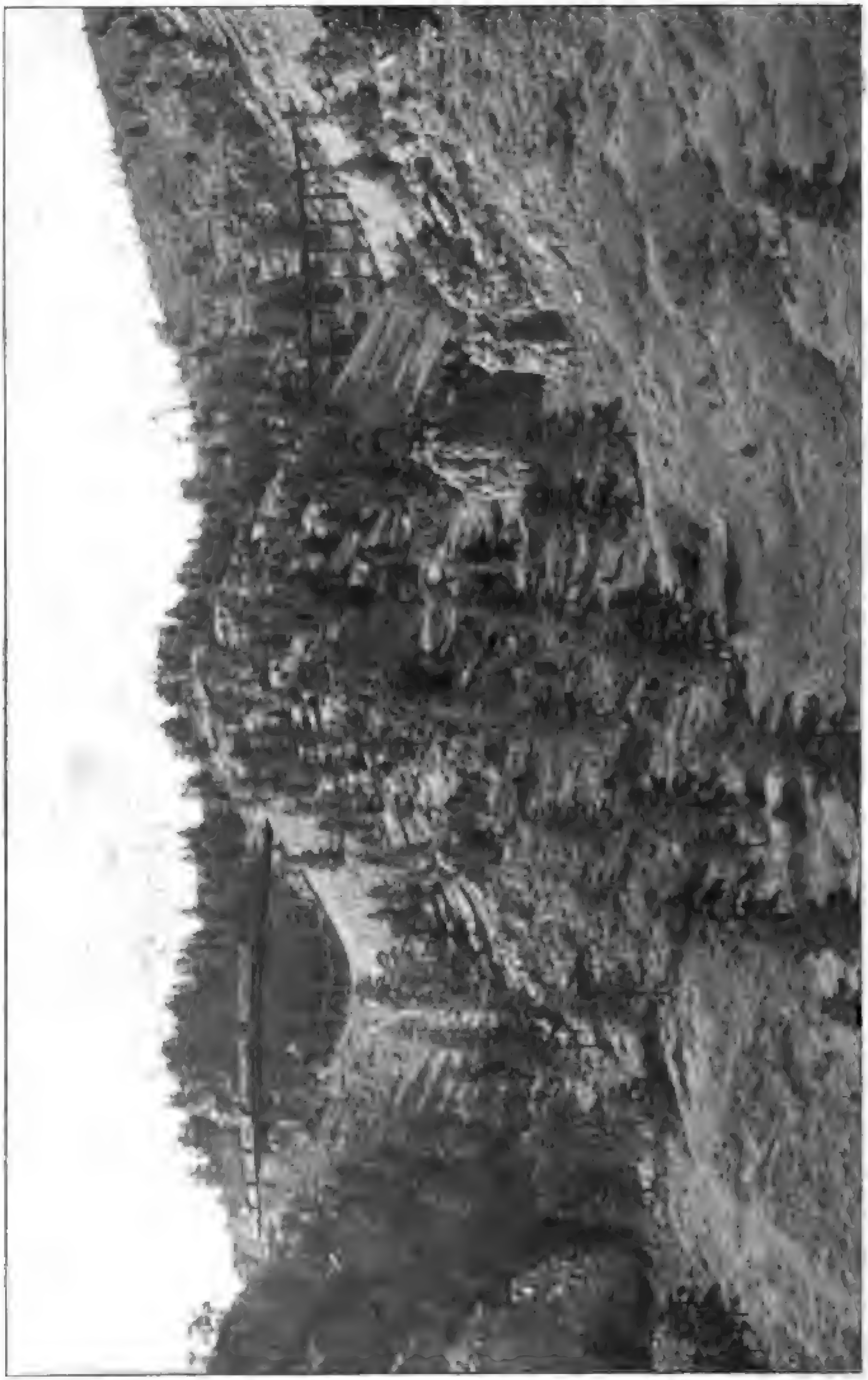
From Lake Morrain a natural channel is followed for 1¾ miles to a second metal pipe-line, 19 to 21 inches in diameter, which has moderate grade for 8000 feet, and then plunges down the steep mountain side for 6000 feet, measured on the slope, having in this total distance a fall of 2417 feet, to the Manitou power station of the Pike's Peak Hydro-Electric Company, located close to the foot of the cog railroad leading to the summit of Pike's Peak.

The pipe on the steep slope is of riveted steel, 19 inches inside diameter, the lower sections being under a static pressure of 1047 pounds, and when in operation under 940 pounds. This pipe, formed in sections 32 feet long for transportation on railway cars, was handled to place on the steep mountain faces by a tramway, the power for moving the tram cars being a cable operated by electricity.

This power station of the Pike's Peak Hydro-Electric Company is in-

THE LOWER PART OF THE PIPE LINE OF THE PIKE'S PEAK POWER COMPANY IS OF STEEL AND IS CARRIED ON AN INCLINED TRESTLE AND AROUND A SHARP CURVE

teresting because of the phenomenal head under which it operates,—2417 feet,—and because of the equipment, which consists of three Pelton water-wheels, each directly connected to General Electric Company generators, rated at 750 KW. at 6600 volts and 66 amperes, making 450 revolutions per minute. The wheels are 7 feet 4 inches in diameter at the pitch line of the buckets, or 7 feet 9 inches over all. Each consists of a steel disk, 1½ inches thick, to which are secured 36 bronze buckets, revolving when in operation at a circumferential speed of 11,000 feet, or 2.08 miles per minute. Water is applied to each wheel through a 2¼-inch nozzle, the volume being controlled by a needle valve and the speed by Lombard governors which deflect the nozzles. There are also two excit-



TWIN BRIDGES ON THE CRIPPLE CREEK SHORT LINE. THE 3½ PER CENT. GRADE OF THE ROAD IS INDICATED BY THE DIFFERENT ELEVATIONS OF THE TWO BRIDGES

ers operated by small water-wheels.

Taking the plant at its rated capacity, it is doubtful if any other locality in the United States can show over 3000 horse-power generated by water in such limited space. It is also doubtful if any plant elsewhere operates under as high hydraulic pressure, except at Vourvrey, Switzerland, where 3030 feet are the head reported as used for an 8000-H. P. hydro-electric plant. The project of utilizing the fall in the Colorado Springs water supply includes a second power plant to be installed in the future above that described, which will operate under 1200 feet head.

In this outline the water has been traced for a distance of 7 miles, falling 5500 feet, of which fall 3121 feet are now utilized; but en route the water is augmented by connection with minor tributaries.

After developing power at the above mentioned station, the water passes to a tank, at an elevation of 6633 feet, which feeds the present 18-inch and 10-inch pipe-lines, 6 miles long, connecting with the distributing system of Colorado Springs, at an average elevation of 6200 feet, the surplus discharging into the city distributing reservoir at 6400 feet elevation.

The two hydro-electric plants mentioned are not operated by the city of Colorado Springs, which cannot enter into the commercial field, but the water is supplied to independent companies. The plant last described furnishes electric light and power to the city of Colorado Springs under charter privileges.

The problem of operating a power station in connection with a city water supply is full of complications, because in the season of large water requirements the demands upon the power plant are less severe than in the winter months, when less water is used in the city. The same holds good for the variations of load at different hours of the day, but the distributing reservoirs can care for this. As waste of water cannot be permitted, it is evident that an adjustment of conflicting interests is essential, and that the best result demands a partial dependence upon the steam auxiliary plant in Colorado Springs.

Another impressive installation is the hydro-electric plant of the Pueblo & Suburban Traction & Lighting Company, on West Beaver Creek, on the slope of Pike's Peak. Five and a half miles east of Victor a steel-faced, rock-filled dam was constructed, forming a reservoir with a capacity of nearly 200,000,000 cubic feet, with the water surface about 9100 feet above sea level, the drainage area above the reservoir dam being 70 square miles. The dam closes an opening in the granite rock 220 feet wide at the base and 450 feet wide at the crest of the dam; the height from bed-rock to the dam crest is 90 feet. The inner slope (steel faced) is inclined 30 degrees and the outer slope 50 degrees from the vertical; the crest is 20 feet thick and the spillway is 60 feet wide.

Water is drawn from this reservoir by means of wooden-stave pipe, 30 inches in diameter, the staves being secured by steel bands spaced from 2¼ to 8-inch centers, according to the head, which in passing depressions reaches 215 feet. This pipe-line, 21,000 feet in length, is constructed through extremely rough country, some of the curves being of less than 100 feet radius, and one compound curve is stated to have a radius of 35 feet. The pipe passes through a tunnel over 1500 feet long, and a portion of it is suspended by cable. See page 494.

In addition to the wooden-stave pipe, 2900 feet of riveted steel pipe, 29 inches in diameter, have been laid, commencing where the static head is 120 feet, and continuing to the power house where the static head is 1165 feet. The shell of the steel pipe section ranges from ¼ to ⅜ inch in thickness, and the pipe is laid on grades varying from 12½ to 57 per cent. At one place this pipe is laid on a bridge

74 feet high and through a tunnel, both of which are on a 40 per cent. gradient.

Water is conveyed from the reservoir through the pipe-line mentioned to four hydro-electric units operating under 1150 feet head, each unit consisting of two Pelton water-wheels, 66 inches in diameter, directly connected to 400-KW. generators. There are also two 30-KW. exciters. Current is transmitted to Victor, 8 miles, and is there transformed to 12,000 volts, part of the power being used at several mines in the Cripple Creek district and the balance carried to Pueblo, 30 miles distant, to operate the city trolley system. Plans for developing additional powers at points further down Beaver Creek have also been prepared.

The portion of the great plain within the range of vision from the summit of Pike's Peak is liberally supplied with irrigation canals, ditches. and reservoirs of great size. Colorado is credited with over 12,000 miles of irrigating canals, which make productive about one million acres of land, and some of the larger enterprises supply portions of the territory embraced in the Pike's Peak region.

One instance which illustrates the magnitude of the irrigating projects, is the enterprise of the Twin Lakes Land & Water Company, to which have been appropriated 750 second-feet from the flow of the Arkansas River. To supplement the normal stream delivery, the company raised the level of Twin Lakes,—two adjacent natural bodies of water in the Rocky Mountains, at an elevation approximating 9200 feet above tide.

Water stored in this combined reservoir, with an area of 2500 acres, is let into the Arkansas River as required, and flows in the stream bed for 160 miles to the head-gates of the company's large canal, which is 40 feet wide at the bottom and 6 feet deep, meandering on the land contours for many miles, and feeding numerous smaller ditches for watering the great area controlled, and several large reservoirs en route.

Under the laws of Colorado water can be stored during the flood season, or at any time when excess water is not needed for direct irrigation, and thereafter turned into the river in times of scarcity; and the same quantity as is let out of the reservoir (with a percentage deducted for seepage and evaporation while in transit in the river) may be taken out of the stream by the irrigation canal entitled to it. At present four days are calculated as the time of travel of the water in covering the 160 miles between Twin Lakes reservoir and the company's head-gates on the Arkansas River, and pending more exact determniation a discount in volume of 10 per cent. is estimated.

To provide ample water supply for its Minnequa steel plant at Pueblo, which turns out 1500 tons of manufactured product a day, and to meet an increased output, the Colorado Fuel & Iron Company have constructed a comprehensive water supply which should deliver to it continuously 50,000,000 gallons of water per day by gravity. The company controls the right to divert 80 second-feet of water from the Arkansas River, and to maintain this a storage reservoir has been constructed on the Lake Fork of the Arkansas River, which the Colorado & Midland Railway follows in reaching Hageman Pass. The function of this reservoir with a storage capacity of 5,640,000,000 gallons is to store the excess water resulting from melting snows, and, under the direction of the State engineer, turn it into the Arkansas River when needed to make up deficiencies.

The water surface of this reservoir covers 820 acres, and is at an elevation of over 10,000 feet above sea level. In maintaining the flow, the water will be discharged from the lake into the Arkansas River, being subject, in following its bed for 130 miles, to discount and time allowance as stated for the Twin Lakes, and is carried to

the head-gates of the ditch line. From these head-gates a conduit has been constructed, 38 miles in length, of which 12 miles consist of wooden-stave pipe, ranging from 54 to 60 inches in diameter, laid in the river bottom within a few miles of the head-gates, and crossing "arroyas," which are deep gashes formed in the plains by water courses. Some of these siphon crossings are short, others approximate a mile in length, the depth varying, but increasing as the conduit approaches the plains reservoirs. The maximum head upon any siphon is 150 feet.

A considerable portion of the conduit is a ditch excavated in the rolling prairie or plains, but much of the work is difficult engineering, such as ditches cut on the faces of cliffs, some of which overhang, or driven through disturbed strata or loose material, where a concrete lining is necessary. On the route there are 25 siphons and 5 tunnels. The lower end of the ditch discharges into a reservoir system established on the plains over 4 miles from the Minnequa steel plant, with which it is connected by a line of 28-inch wooden-stave pipe, and an additional line, 48 inches in diameter, of the same construction, is now being laid. The upper reservoir holds about 1,000,000,000 gallons, and the lower one, 500,000,000 gallons, this latter giving a head on the works of 150 feet. There is also a supplementary reservoir at a lower elevation, with a capacity of 500,000,000 gallons.

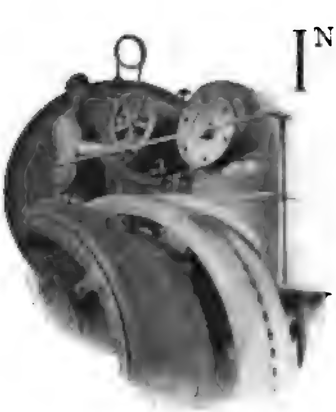
While this installation is expensive in first cost, the fact that no pumping will be required is to its advantage, and it is probable that the interest and sinking fund charges plus the necessary operating expenses will compare favourably with the pumping expense at other steel works where a similar amount of water is mechanically elevated.

The foregoing statement is merely suggestive of the many problems in engineering which have been met in the Pike's Peak region. They demonstrate the progressive and bold spirit which has overcome so many difficulties in the commercial development of territory, which, a half-century ago, was believed to be uninhabitable and a barrier to human progress. It is in surmounting difficulties that man makes his best achievements, and few localities are more prolific in evidence of this than the Pike's Peak region.

RECIPROCATING STEAM ENGINES vs. STEAM TURBINES

A COMPARISON OF OPERATION BETWEEN TWO POWER HOUSES OF MODERN TYPE

By W. P. Hancock



IN an attempt to say anything referring to comparsons between engine and steam turbine stations, it seems reasonable to assume that statements based on records made from practical experience and the commercial use of both of the above types of steam apparatus will be more valuable and more interesting at this time than theoretical deductions, which, while absolutely necessary in the designing of the apparatus, and also in making necessary changes, in order to obtain a test performance from the unit as nearly correct as possible, are not by any means conclusive.

An athlete, or a race-horse, about to compete for honours, is fitted to the minute, with a view to have them make the supreme effort of their lives, and they perform, we will say, satisfactorily, but what then occurs? A long rest is given, and various things are considered, in order that the man, or the horse, may, within a reasonable period, again successfully compete. Therefore, we may test a new unit, of a new type, and it may show a performance which complies with the builder's guarantee, and if it does, that practically absolves the builder; but the buyer of the unit will be thoroughly satisfied only when he can see by consulting his cost sheets that in a full year of operation the new unit has proved beyond question that it is less expensive to operate, and, to a degree, that it will be profitable for the user to further install and operate that type of unit. In other words, what is most valuable and interesting to know is the result of a continuous, instead of a test, performance of the new unit.

I shall, therefore, speak of a power house operated by reciprocating engines of one of the best types, and a power house operated by steam turbines of a new type now very prominent in the market. Both of these power houses are situated on the water front. Both use the same grade of coal, costing approximately the same per ton. The circulating water for both comes from the same source, as does the boiler feed water, the latter being taken from city water service. Both power houses are operated by one set of men, and the loading of the stations is conducted with a view to obtaining the lowest cost per kiliwatt-hour consistent with good and continuous service.

I shall speak of the performance of these power houses, as shown for the calendar year 1904 for the engine station, and the calendar year 1905 for the turbine station; and I have chosen these years for the reason that in each case each station in those periods had a load factor that enabled it to show a satisfactory performance, if its capabilities had been

TABLE I.—EQUIPMENT OF THE TWO POWER HOUSES.

	Engine Station.	Turbine Station.
Units	6—1600 K.W. cycles 60.	2—5000 K.W. cycles 60.
Boilers, water tube	12—550 H.P. No superheaters.	16—512 H.P. Superheaters.
Furnaces	Hand-fired.	Mechanical stokers.
Auxiliaries	Principally steam. Modern types.	Principally steam. Modern types.
Builder's rating (total)	9000 K.W.	10,000 K.W.

correctly estimated; and I will add, there is no doubt today about that part of the matter, in either case.

Table I. gives approximately the equipment of each power house and, later, a division of the labour as charged to the pay roll will be given.

The furnaces in the engine station are hand-fired and not economical if we refer to labour, but very much so if we refer to evaporation, fast steaming qualities and repairs. The turbine station furnaces have mechanical stokers, and, naturally, the labour expense with them is much less.

The fuel used is "New River" bituminous coal, and an analysis and the method of making analyses follow:—Three samples of coal were taken each day. The samples taken on Wednesday, Thursday and Friday were combined, and one analysis was made from them.

The samples taken on Saturday, Sunday, Monday and Tuesday were combined and an analysis was made from them, or two analyses per week from the combined samples.

	1904.	1905.
Moisture in sample, per cent	4.24	4.24
B. T. U. per lb. dry coal	14,834	14,715
Organic and volatile, per cent	24.12	24.98
Fixed carbon, per cent	70.96	69.81
Ash, per cent	4.92	5.21

After looking over the analyses for both years, it seems plain that the fuels were nearly alike in quality. This is one of the greatest factors necessary to make a consistent comparison. The cost of the coal per short ton in 1905 was about 2 per cent. less than the cost in 1904, and, therefore, that particular point would tend to favour the operation of the turbine station on total cost, but we notice also that the B. T. U. in the 1905 coal were less than in the 1904 coal, and also that the ash was greater to a small degree, and these conditions therefore again tend toward a fair comparison.

The other conditions of operation were as given in Table II.

The boiler feed water for both power houses costs alike per thousand cubic feet, and, as I have said, is taken from the same source.

I will also say that all of the labour is classified and paid a standard wage under the classification, all of which tends toward making the comparison a fair one, that is to say, no advantage accrues to lessen the cost of operation of one station over the other by a discrimination in the hiring of men, at a price which would benefit one station over the other.

Then, to start with the labour in the engine station boiler room which has hand-fired furnaces, we find that with a peak load in December of 10,175 K. W., we operated ten 550-H. P. boilers with a maximum of twenty-five men for twenty-four hours, including a fire room engineer. The average number of men employed in the boiler room for the total year was twenty-three.

The total coal consumed was 44,813 short tons, and the average number of tons handled per day of twenty-four hours was 123. The number of firemen employed was fifteen, and the water-tenders did some firing also. The average amount of coal handled by each man (floor to furnace) was, per day of eight hours, 6.8 short tons. The refuse from fires, ash pits and boilers, for the year, was 3,736 tons, all of which was

TABLE II.

	Engine Station, 1904.	Turbine Station, 1905.
Output, kilowatt-hours	37,912,000	33,840,800
Load factor $\left\{\frac{\text{Average}}{\text{Av. max.}}\right\}$	0.588%	0.645
Short tons coal consumed	44,813	44,364
Pounds coal per kilowatt-hour	2.36	2.62
B. T. U. per lb. dry coal	14,834	14,715
Steam pressure	160	175
Feed water temperature, Fah.°	183	149
Vacuum (inches mercury)	26	28.5
Superheat, degrees	None	150

taken from the floor of the boiler room to the yard by the coal passers, that work being a part of their duties, additional to passing coal and cleaning.

It should also be borne in mind that all of these men did not work all of the time, as under existing rules all of the men employed on the system seven days per week are entitled to and do receive fourteen days off in the course of the year, without loss of salary, and this amount of time may be taken as a man may desire, subject to the approval of the chief engineer, for either vacation or sick leave, and between April 1 and September 1.

The total fire room force was divided as follows in the engine-operated station:—

Fire room engineers	1	Average number of men for each type of work for the year 1904.
Water tenders	3	
Firemen	15	
Coal passers	3	
Cleaners	1	
Total	23	

Relative to the disposal of ashes, I will say that this item is one which incurs expense, as the total output of ashes from both power houses has to be hauled away by contract; but this has no weight in making a comparison, and I mention the matter only in connection with the fact that some companies receive a benefit from the sale of ashes, which has shown a credit to operating expenses of 1 per cent.

Having covered the engine station boiler room items, except in the comparison of costs, which will come later in tabulated form, we will take up the boiler room of the turbine station, where no manual labour is employed to handle coal, and mechanical stokers are in operation.

The ashes go to the pits, which have a capacity sufficient so that removal is necessary only once in twenty-four hours. Of course, this is a very different proposition for handling and burning coal as compared with the one in the engine station, as well as a most important one, for it is true that no matter where you save the cost, it all shows in the ultimate cost per kilowatt-hour manufactured.

Then to take up the labour in the turbine station boiler room, we find that with a peak load of 11,025 K. W. in November, 1905, we operated eight 512-H. P. boilers with a maximum of eleven men for the twenty-four hours, including a fire room engineer. The average number of men employed in this boiler room for the total year was eleven.

The total coal consumed for the year was 44,364 short tons, and the average number of tons handled per day of twenty-four hours was 121.2. The number of firemen employed was four. The same vacation privileges obtain as in the engine station, and for all employees in the room.

A summary of the total operating fire room labour in each station is given in Table III.

TABLE III.

	Engine Station Boiler Room.	Turbine Station Boiler Room.
Fire room engineers	1	1
Water tenders	3	3
Firemen	15	4
Coal passers	3	3
Cleaners	1	..
Total men	23	11

I may say with reference to the coal passers mentioned in the summary for the turbine station, that there is installed in that station, over each boiler, a set of Howe beam scales, so arranged that each chute of coal can be weighed and recorded before it goes to its respective feed hopper and to the fires, and it is a part of the duty of these coal passers to weigh and record the amounts of coal sent down, and, additional also, to keep the conductors from chutes to hopper clear, and, incidentally, to keep his particular territory swept and as clean as can be under business conditions.

Now to compare the labour employed in the turbine station, as compared with that of the engine station boiler room, we can refer to Table IV., and in so doing we will assume the total number of men employed in

TABLE IV.

	Fireroom Labour Engine Station.	% of each to the Total Engine Station.	Fireroom Labour Turbine Station.	% of each to Total of Engine Station.	Ratio Turbine to Engine.	Turbine Decrease over Engine.
Fireroom engineers	1	4.3	1	4.3	1.000	.0
Water tenders	3	13.1	3	13.1	1.000	.0
Firemen	15	65.2	4	17.4	0.267	73.3
Coal passers	3	13.1	3	13.1	1.000	....
Cleaners	1	4.3	0	....	....	100.0
	23 men	100.0%	11 men	47.9%	0.479%	52.%

the engine station to be represented by 100 as a standard, and that each type of labour is a percentage of that 100.

Explanatory of Table IV. we find that of the total labour employed in the engine station the fire room engineer is one-twenty-third, or 4.3 per cent; the water tenders are three-twenty-thirds, or 13.1 per cent.; firemen fifteen-twenty-thirds, or 65.2 per cent.; coal passers three-twenty-thirds, or 13.1 per cent.; cleaners one-twenty-third, or 4.3 per cent., making the total of 100 per cent.

As to the number of men employed in the turbine boiler room as compared with those in the engine boiler room, we find by still adhering to the 100 per cent. used in distributing in the case of the engine portion that the fire room engineers, water tenders and coal passers are of the same percentage of value, but that the firemen are only 17.4 per cent., or four-twenty-thirds of the total of that type of labour used in the engine portion, and that no cleaner is used in the turbine portion, as spare time is available at low-load periods to enable this work to be done by the regular force.

Then it follows that the labour of firemen is, in the turbine portion, 26.7 per cent. of what it is in the engine portion, representing a decrease of 73.3 per cent., and as all firemen receive the same wages the result is a decrease in cost between the two boiler rooms, in direct proportion to the percentage given. The same also is true of the value of the decrease of cleaner labour, as all of this type of labour receives the same wages.

We find also that the turbine boiler room force in total is eleven-twenty-thirds of that of the engine boiler room, or 47.9 per cent. (fractions of percentage may vary one or two-tenths due to additions of decimals of second place).

It appears to be plain that from the existing boiler room in question, with its hand-fired and, in part, economically operated furnaces, we have stepped forward to something of the same general utility, but also to something vastly more economical from the labour standpoint, and additional to that we do not have to employ so many men to burn a given amount of coal, and have it burned economically, as we did in the first-mentioned boiler room. There are times and conditions, as every operator and every power producer for that matter knows, when it is an easier matter to produce and place before the fires half a dozen first-class firemen, than it is to obtain four times that number. Additional to economy of labour, the above is one of the greatest of incentives for installation of a good type of mechanical stoker.

We have not, however, covered all of the ground which should be covered in the boiler room expense, for the question of repairs and renewals should be compared in a thorough manner also, and to do this I shall add to the previous table a comparison of repairs in both of the boiler rooms, and then show a total boiler room operating and repair expense in comparison.

The total repair and renewal cost in the engine station boiler room for 1904 was 2.1 per cent. of the total cost per K. W.-hour, being divided as follows:—Grates, 1.4 per cent.; boilers, 0.7 per cent. Taking the combined cost of boiler room repairs

on engine station as 100, we find it divided in proportions as follows:—

Grates, 1.4 per cent of the total cost per kilowatt-hour, and 66.7 per cent. of the total cost of boiler room repairs.

Boilers, 0.7 per cent. of the total cost per kilowatt-hour, and 33.3 per cent. of the total cost of boiler room repairs.

The cost of repairs on grates in the turbine station boiler room was 100 per cent. of the total repairs in the engine station boiler room, while the cost of boiler repairs in the turbine station was 9.5 per cent of the engine station boiler room repairs. The figures have been collected in Table V.

making no qualification as to such a statement.

As I expect that a reader of this paper may at this time wonder how the coal is handled, and where the expense of such work is charged, I will state that the fuel for these power houses is shipped by water, and that the total cost of a short ton delivered to both the power house boiler rooms includes:—

1.—The base price of the coal f.o.b. tide water.

2.—The freight.

3.—The insurance.

4.—The discharging to storage field.

5.—The handling from storage field to bunkers over boilers.

TABLE V.

	Percentage of Total Cost per K. W. H. Eng. Sta.	Proportion of 100 Engine Station.	Turb. Sta. % of each Acct. to Total Cost of Eng. Sta.	Percentage of Boiler Room Repairs Turb. Sta. to Total of Eng. Sta.	Ratio Turbine to Engine.	+=Increase. —=Decrease.
Grates	1.4	66.7	2.1	100.0	1.500	+.50
Boiler	0.7	33.3	0.2	9.5	0.286	—.71
	2.1	100.0	2.3	109.5	1.095	+9.5

Then the total cost of the labour and repairs of the turbine station boiler room, as compared to the engine station boiler room, was as given in Table VI.

6.—The handling over in storage field in case fuel heats.

7.—The maintenance of all machinery in the coal handling system.

All of the above items are charged

TABLE VI.

Boiler Room.	Percentage Total Cost K. W. H. Engine Sta.	Percentage of Total Boiler Room Cost.	Percentage of Total Cost K. W. H. Turb. Station to Engine Sta	Percentage of Total Cost Turbine to Engine.	Ratio Turbine to Engine.	Turbine to +=Increase. Engine to —=Decrease.
Total labour	8.5	80.2	4.9	46.2	0.576	—42.3%
Total repairs	2.1	19.8	2.3	21.7	1.095	+9.5%
Total cost	10.6	100.0	7.2	67.9		

I have gone over the boiler room expenses in rather a detailed manner, for the reason that in making a comparison of two stations, one showing better as to cost of operating and maintenance than the other, it seems to me to be quite necessary to show just where and how the saving is effected in the one case, so that such credit as may be due to improvements in apparatus should not be misplaced or diverted to wrong channels, by reason of making the sweeping assertion that the difference in total cost between the two power houses is a certain percentage, and

to "Stock Fuel," and at the end of each month the total cost, divided by the short tons of coal used, gives the price per short ton, and the amount is then charged to "Operating Fuel," and "Stock Fuel" is credited.

As I have said before, all fuel is weighed in each fire room before going to the fires. Before beginning a comparison on the cost of operation and maintenance of the engine and turbine rooms proper, I will say that in both of these rooms are located the auxiliaries for such units as are operated for the generation of current, and the boiler feed pumps

also are there, so that, broadly speaking, everything in the nature of moving machinery, whether steam or electrically driven, is directly under the observation of the watch engineers.

Exception only to the above are the motors which operate the mechanical stokers in the turbine station boiler room. In other words, the facility afforded in each room for men to operate quickly and accurately is good, and with everything taken into consideration the facilities are very similar. Excellent opportunity is thus given for a fair comparison on the labour cost of operating in both locations.

It is proper to explain at this time that before the turbine station was erected the services of the chief engineer, the chief operator, and their respective first assistants, were charged wholly to the engine station, and at the present time are divided equally between the two stations, and this distribution of labour will be fully set forth in tabulated form in this article.

We began at the boiler room end by making a comparison of the labour, and therefore we will begin with this item in the generating rooms also. Table VII. gives the number of men engaged in the operation of steam apparatus in the year 1904 in the engine station, and year 1905 in the turbine station, and, as in division of fire room labour, we will assume the engine room labour to be 100 per cent. as the standard.

For the operation of the electrical portion of the engine station in 1904 nine men were employed, and as the two power houses are located on either side of the operating room, it was possible to operate in 1905 both the engine and turbine stations without increasing the pay roll, and the labour cost has been divided equally between the two stations, and that being the fact, it does not seem necessary to tabulate.

I will say, however, that the electrical operating force is composed of the following men:—

Chief operator	1
Asst. operator	1
Watch operators	3
Asst. watch operators	4
Total men	9

The engine station contains the motor-generators for city lighting. This is practically a division in itself, in that none of the men employed on the floor is employed for anything except that work; in other words, they do nothing toward operating any of the electrical generating units, and are not employed on the switchboards for regulating or other purposes. It is a fact also, that the two stations are provided with three telephone operators, one janitor and three watchmen, and these all are charged pro rata between the generating and the electrical room expense of each of the two stations; in other words, their expense is divided into four equal portions, one-fourth to each of two divisions in two stations.

In a tabulated form which appears later in this article all labour will be shown, that is to say in the columns showing the proportion of each labour cost to the total generated cost, all of the labour will have been included, whether it has previously been shown in comparisons of labour or not, and it should be borne

TABLE VII.

	1904. Engine.	1905. Turbine.	1904. Engine % of Total.	1905. Turbine % of Engine Total.	Ratio Turbine to Engine.	Decrease Turbine.
Chief engineer	1	0.5	4.2	2.1	0.50	50%
Asst. engineer	1	0.5	4.2	2.1	0.50	50%
Watch engineers	3	1.5	12.5	6.3	0.50	50%
Condenser men	1	0.0	4.2	....	....	100%
Oilers	13	7.0	54.	29.1	....	46%
Cleaners	4	1.0	16.7	4.3	0.25	75%
Repair men	1	.5	4.2	2.1	0.50	50%
	24	11.0	100.0	46.0	.460	54%

TABLE VIII.

Accounts.	Account Number.	Eng. Sta. 1904 % of Each Account to Total Cost.	Turb. Sta. 1905 % of Each Account to Total of Eng. Sta.	Ratio Turbine Station to Engine Station.	+=% Increase. —=% Decrease
Fuel	O 41	60.3	65.5	1.086	+8.6
Water	O 42	5.1	1.3	0.255	—74.5
Oil and waste	O 43	1.4	0.7	0.500	—50.0
Total labour	....	24.2	13.4	0.554	—44.6
Boiler labour	O 44	8.5	4.9	0.576	—42.4
Engine labour	O 45	9.0	5.2	0.578	—42.2
Electrical labour	O 46	6.7	3.3	0.493	—50.7
Battery labour	O 47	....	....	......	......
Battery supplies	O 48	....	....	......	......
Sundries	O 49	1.8	1.1	0.611	—38.9
Total operating	....	92.8	82.0	0.884	—11.6
Station buildings	R 52	.7	0.3	0.428	—57.2
Mechanical apparatus	R 53	2.1	1.1	0.524	—47.6
Grates	R 54–02	1.4	2.1	1.500	+50.0
Boilers	R 54–09	0.7	0.2	0.286	—71.4
Engines	R 55	0.9	0.2	0.222	—77.8
Dynamos	R 56	1.1	0.2	0.182	—81.8
Electrical apparatus	R 57	0.3	0.3	1.000	00.0
Batteries	R 58	....	....	......	......
Total repairs and renewals	....	7.2	4.4	0.611	—38.9
Total cost of total station	....	100.0	86.4	0.864	—13.6
Kilowatt hours manufactured		100.0	89.3	0.893	—10.7
Coal consumed, short tons		100.0	99.0	0.990	—1.0
Coal consumed per K. W. H.		100.0	111.0	1.100	+11.0
Average cost coal short ton		100.0	98.0	0.980	—2.0
Load factor		100.0	1.09	1.090	+9.0
Total cost per K. W. H.		100.0	86.4	0.864	—13.6

in mind that the labour omitted in previous tables, but appearing in those to follow, does not in any way affect the accuracy of comparison, because it is distributed equally to four distinct accounts in the operating expenses of the two stations.

I would also add that we make a practice of effecting minor repairs with the operating force in each division, but we do not carry a repair force in the generating department, having found by experience that it is less expensive to call in various firms who are equipped with tools and help, which give prompt and efficient service in that line.

All the testing is done by our own laboratory, on which we draw orders the same as if it were an outside concern, and these orders are charged direct to the operating accounts of the generating system.

Table VIII. gives a comparison of the turbine station and that operated by engines, using 100 as the total cost for the year for the engine station, and in this table is included all labour of any and every nature, as well as every other expense necessary to operate and maintain a generating system.

The operation of the turbine station from which the above records have accrued was not satisfactory from several points of view in 1905, and for the following reasons:—

First, we had not sufficient transformer capacity between stations to enable us to load the turbines economically, and at the same time insure continuity of service. I may say in explanation of this that the engine station generates at 2,300 volts and the turbine at 6,900, and the transformer arrangement is such as to admit of changing load of either station to the other to the extent of the transformer capacity.

Second, the turbine station was operated commercially for the first time in October, 1904, and the construction of the station was not complete, and there were a great many interruptions of operation, not due to the units, but to changes that necessitated taking units out of service. The banking of fires was thus made necessary, and consequently a great loss of heat value was incurred.

TABLE IX.

Accounts.	Account Numbers.	Engine Sta. Last 9 Mos. 1904 % of Each Account to Total Cost.	Turbine Sta. First 9 Mos. of Fiscal Year % of Each Account to Total of Engine Sta.	Ratio Turbine Sta. to Engine Station.	+ =% Increase. — =% Decrease
Fuel	O 41	58.7	61.6	1.049	+4.9
Water	O 42	5.1	1.3	0.255	—74.5
Oil and waste	O 43	1.4	0.5	0.357	—64.3
Total labour	....	25.3	10.7	0.423	—57.7
Boiler labour	O 44	8.8	4.0	0.454	—54.6
Engine labour	O 45	9.5	4.1	0.431	—56.9
Electrical labour	O 46	7.0	2.6	0.371	—62.9
Battery labour	O 47	....	....	.....	......
Battery supplies	O 48	....	....	.....	....
Sundries	O 49	2.0	1.0	0.500	—50.0
Total operating	....	92.5	75.1	0.812	—18.8
Station building	R 52	1.0	0.2	0.200	—80.0
Mechanical apparatus	R 53	1.2	1.3	1.083	+8.3
Grates	R 54-02	1.8	1.8	1.000	......
Boilers	R 54-09	0.8	....	.....	—100.0
Engines	R 55	0.9	0.2	0.222	—77.8
Dynamos	R 56	1.5	*0.2	.....	—100.0
Electrical apparatus	R 57	0.3	....	.....	—100.0
Batteries	R 58	....	....	.....	......
Total repairs	....	7.5	3.3	0.440	—56.0
Total cost of total station	....	100.0	78.4	0.784	—21.6
Kilowatt hours manufactured		100.0	115.4	1.15	+15.4
Coal consumed short ton		100.0	122.2	1.22	+22.2
Coal consumed per K. W. H.		100.0	106.0	1.06	+6.0
Average cost per short ton		100.0	99.1	0.991	—0.9
Load factor		100.0	108.5	1.08	+8.5
Total cost per K. W. H.		100.0	78.4	0.784	—21.6

* Credit.

In the meatime improvements were being made on parts of units of the turbine type, and it was finally decided to incorporate some of them in connection with the units then in operation, which, of course, caused more interruption of operation; but it was time well spent.

At the beginning of the fiscal year July 1, 1905, we were fairly well completed with reference to the construction of the station, and had an opportunity to "work the units out" under fairly reasonable conditions. As a matter of fact, in the nine months of the fiscal year ended April 1, 1906, we manufactured 94.1 per cent. as many killowatts as we did in the twelve months of the calendar year 1905, and with practically uninterrupted operation, with the exception of some instances of steam line repairs and condenser tube troubles which are likely to occur to a greater or less extent.

The repairs were small in the calendar year 1905, but the first nine months of the fiscal year show very much less; so also does the cost of operating, and the total generated cost per kilowatt-hour.

As for the turbine units themselves, I have no hesitation in saying that as load carriers they are "gluttons," and the maintenance is exceedingly small in comparison with any other unit that we operate. Table IX. gives the operation of the turbine station for the first nine months of the fiscal year, July 1, 1905, to April 1, 1906, in comparison with the engine station for the last nine months of the calendar year 1904, for that portion of 1904 gave the engine station the best load—as a matter of fact, the best load factor.

Table X. shows the division of labour in both of these power houses at the present time, so that it may be made plain how the services of every man employed are charged on the pay roll, and also to show that every person that is connected in any way with operation of the generating system is charged to it.

I may add at this time that in three recent months of the fiscal year, we were obliged to use field-

stored coal which had been on the ground for more than a year. This was very dirty. This condition was brought about by reason of the difficulties of the coal people, on whom we principally depend for our fuel, and additional to that fact shipments were much delayed, on account of heavy weather at sea.

A few words with reference to the "Increases" and "Decreases" as shown in the totals in Table IX. The "fuel," for instance, looks high for the turbine station as compared with that of the engine station, but in the very next account, which is "water," we find a heavy reduction in cost. Just what this means may be found by adding together the figures which represent the proportions of "fuel" and "water" to the total cost of a killowatt-hour, in the engine station for 1904, as per the table for nine months, and we find we have for the sum of the two items 63.8.

Add the same corresponding items in the same table for the turbine station, and we find the result to be 62.9.

Total cost fuel and water, engine station	63.8
Total cost fuel and water, turbine station	62.9
	0.9

This represents 1.41 per cent. less expense in operating of the turbine station.

The above is not quite true, because we also find in the same table that the cost of fuel for the turbine 1905-6 was 0.9 per cent. less than in the case of the engine station for 1904, and to correct and obtain a true result, the fuel and water figures for the turbine station should be $61.6 + 0.9 + 1.3 = 63.8$ = total comparative cost of "fuel" and "water" for the turbine station for 1905-6.

The price of boiler feed water is the same for both stations, and always has been within the writer's experience, and it is only by difference in conditions that vary the price of coal delivered in the fire room, that the costs of these two items in both stations are exactly alike, and that under exact comparative conditions the excess in the cost of the "fuel" is offset by the decrease in the cost of boiler feed water.

TABLE X.—Distribution of Labor on Payroll for the Engine and Turbine Stations, Month of March, 1906.

O44 Boiler Room Labour	Engine Station.	Turbine Station.	Total Men.
Chief engineer	0.25	0.25	0.50
Asst. engineer	0.25	0.25	0.50
Fire room engineer	1.00	1.00	2.00
Water tenders	3.00	3.00	6.00
Firemen	4.00	5.00	9.00
Repair men	0.00	1.00	1.00
Coal passers	1.00	3.00	4.00
Total boiler room labour	9.50	13.50	23.00
O45 generating room labour			
Chief engineer	0.25	0.25	0.50
Asst. engineer	0.25	0.25	0.50
Watch engineers	1.50	1.50	3.00
Oilers	5.00	6.00	11.00
Condenser men	1.00	0.00	1.00
Repair men	0.50	0.50	1.00
Cleaners	2.50	1.50	4.00
Telephone operators	0.75	0.75	1.50
Janitor	0.25	0.25	0.50
Watchmen	0.75	0.75	1.50
Total gen. room labour	12.75	11.75	24.50
O46 electrical room labour			
Chief operator	0.50	0.50	1.00
Asst. operator	0.50	0.50	1.00
Watch operators	1.50	1.50	3.00
Asst. watch operators	2.00	2.00	4.00
Telephone operators	0.75	0.75	1.50
Janitor	0.25	0.25	0.50
Watchmen	0.75	0.75	1.50
Total elec. room labour	6.25	6.25	12.50
Total divided labour both stations	28.50	31.50	60.00

The decrease in proportionate cost of oil and water is easily accounted for when we recall that in one case, that of the engine station, we are using cylinder oil for a 9,000 K. W. plant with six cross-compound engines, and auxiliaries, as against a 10,000 K. W. turbine plant with cylinder oil in use for auxiliaries only.

The "boiler labour" decrease is accounted for principally by the fact that in one case we have hand-fired furnaces, and in the other mechanical stokers, but in both cases a close watch is kept on the amount of labour employed. The "engine labour" decrease is due to the fact that a cross-compound engine of 2,240 H. P. is not oiled well and economically with less than one man on each of three watches, while in the turbine room the auxiliaries are nearly all there is to look after in this line of work.

The "electrical labour" decrease is

due to the fact that the electrical controlling devices for both power houses are so situated (between the two) that we have not found it necessary thus far to increase the labour expense in order to operate successfully.

"Sundries" is rather an indefinite account, and is subject to such charges as cannot properly be charged to accounts more clearly defined. It contains such charges as boiler compound, petty cash, etc., but nevertheless it is purely an operating account, and liable to small variation.

On "repairs station buildings"—the engine station is older than the turbine structure and naturally would call for a greater outlay for repairs, although our practice is to make repairs on everything the moment they seem necessary, and not let them multiply or enlarge.

"Repairs mechanical apparatus," include everything which is a part of the generating system, but not parts of moving machinery, as, for instance, steam line, condensers, tools, etc.

The increased cost of grate repairs is due to the fact that the boilers do heavy work, and we use a coal of high carbon value, as the analysis will show, and under these conditions, which are the same as in the engine station, we have so far been unable to hold the expense to any lower level than is shown in the table.

There is nothing to complain of, however, if we take into consideration the decrease in cost of boiler room labour with mechanical stokers in use, as against a less repair cost and a very much higher cost for labour with hand-fired furnaces.

Boiler repairs should not vary much in either case, except there be valves to be renewed or some similar expense, which comes once in a great while and which naturally might occur at very different periods, where one station has been in operation seven or eight years, while the one in comparison has been operated a much shorter period.

Repairs on turbines will always, in the writer's opinion, be less than on reciprocating engines. That is the deduction after operating the turbine units nearly two years, and keeping a close watch on this item of expense.

Of course, I refer to the turbines in the power house under comparison, as I have no reason for comparing with any other type.

With reference to repairs on "dynamos" in the turbine station, experience with this portion of the turbine unit indicates that repairs will be exceedingly small; in fact, the tables show them to be such, but I refer especially to the future.

Repairs on "electrical apparatus" are very small, and refer to switchboards, oil switches, instruments, and in fact all apparatus within the territory covered by the electrical operating room.

Of "batteries" there is nothing to say, as the only one connected with the turbine station is a small one floating on the excitation system, and the expense of maintenance thus far is negligible.

Concluding, I will say that a fair and true commercial comparison of the two types of stations is what I have intended to give, and I have shown that comparison by using records which have accumulated day by day, in the actual commercial operation of one of the large lighting and power systems of the country, and one of the successful ones from a financial point of view.

WHAT CAN AMERICA LEARN FROM GREAT BRITAIN IN TRANSPORTATION?

GROWTH OF THE MOTOR-TRAIN AND MOTOR-BUS

By Archibald S. Hurd

IT may astonish the American public to learn that they can gain any hints from Great Britain in the matter of transportation. The fact which everyone realizes is that Great Britain owes a great debt to American engineers and financiers. It was they who first convinced the British people that a large part of their lives was thrown away in slow and cumbrous traveling, and it was they who preached the sound policy of the "scrap heap" for out-of-date machinery.

For years past British expresses between distant towns have rivalled the best services in America and on the Continent of Europe, but it needed the American engineer to teach the six millions who live in London the wastefulness of the slow and inconvenient methods of getting to and from their work which existed a few years ago, and still exists practically throughout the whole of the British metropolis which lies to the north of the Thames.

Probably the population in Northern London amounts to two and a half or three million persons, and those who have business in the city go to their shops or offices either by heavy, noisy, horse-drawn buses, by tedious horse trams or by trains which stop at practically all intermediate stations, and take from thirty to forty minues to accomplish a journey of four to six miles. Those who live on the heights of Hempstead and desire to reach the city by train, have to travel by a circuitous route to Dalston and then back again to the East End before the train bends in to the central district, making an irregular three-quarters' circle.

There is a direct route to the city by tramcar. The distance is just over four miles, and as the cars are drawn by horses and may be stopped at any point by passengers who desire to enter or leave, it is not astonishing that the journey occupies three-quarters of an hour. Throughout Great Britain, although provincial towns are better served than the capital of the British Empire, parallel instances of slow, expensive and inconvenient means of transit may be found. America can learn nothing from Great Britain in this respect.

The American capitalist and his at-

endant engineer appeared on the scene a few years ago and introduced the "tube" railway running from the Bank of England to Shepherd's Bush, a southern suburb. The project was one of the sensations of the year in Great Britain. The Englishman loves to travel in the open air, but when the choice lay between a snail-like omnibus, London's travelling Noah's Ark, and the quick railway service of the "tube" railway, the business man was compelled to choose the newer and swifter means of locomotion.

The success of the "tube" railway was so instantaneous and remarkable, that a score of other schemes were immediately elaborated and Parliamentary sanction was sought. Competition between the "tube" railway and horse-drawn trams and buses, it was at once seen, could end only in favour of the former. Traffic receipts of the great tram and bus companies fell to an alarming extent, and those responsible at once realized that the alternative to bankruptcy was some better form of traction.

It may be ascribed by Americans to insular prejudice, but there is every reason to believe that in ten years' time London will be served in the matter of quick communication between its various suburbs and its great business center better than any city on the American continent. The financial collapse which threatened the old-fashioned bus and tram companies led to a series of experiments with motor-buses, with the result that various companies are placing on the streets of London several hundred efficient cars.

Some of the new vehicles of the London Road Car Company are driven by petrol motors of 24 horse-power, of the Durkopp and Germain types, and carry 32 passengers, whilst others are propelled by steam (generated by the combustion of crude petroleum) of 16 horse-power, by Clarkson, of Chelmsford, carrying 14

A MOTOR-TRAIN "HALTE" ON THE GREAT WESTERN RAILWAY

ONE OF THE MOTOR-OMNIBUSES OF THE GREAT WESTERN RAILWAY. LUGGAGE IS CARRIED ON TOP

or 15 passengers. The speed of these vehicles is 50 per cent greater than that of the horse-cars, and two motor cars do the work of three horse cars, whilst the 50 new omnibuses ordered by one company will enable from 600 to 700 horses to be dispensed with and a great saving of space in depots and stables to be effected. The cost of maintenance and running the new cars is reassuring, especially as the cost of tires is working out at a lower figure than was once feared.*

Unlike most American cars, practically all the buses and trams in Great Britain have seats on top. There is, as already mentioned, nothing which the English enjoy so much as being able to travel in the open air. Probably the outdoor life which Londoners, like the residents of other big towns in Great Britain, lead, is responsible in no small measure for the fact that the British metropolis, in spite of its congestion of population and its huge army of desperately poor residents, is the healthiest city in the world. A ride on an outside seat of a tram or a bus is a luxury in which the poorest traveler indulges in the coldest weather. It is not difficult to see, in view of this love for fresh air, what the probable outcome will be when "tube" railways and quick electric tram-cars and buses will be in direct and well-developed competition a few years hence.

The "tube" trains have been constructed at an immense capital outlay—a charge which the trams have to bear in far less degree and the buses not at all, though the wear and tear of buses is greater than in the case of trams or trains. Already on a small scale the verdict has gone in favour of the road vehicle. A service of motor-buses runs daily between Shepherd's Bush and Oxford Circus, and Londoners who were astonished at the quickness and cheapness of the "twopenny tube" are bewildered to find that they can travel by bus for

* It may be interesting in connection with this to refer to the article on "Motor Omnibuses for Public Passenger Service" in the May number of this magazine.—The Editor.

ONE OF MANY PUBLIC MOTOR-OMNIBUSES NOW RUNNING IN LONDON

short distances as fast as the underground railway can carry them, at just half the price.

The success which has thus far attended the motor-omnibus has been so instantaneous and complete that already the opinion is expressed that the "tube" railways, which are now spreading out in all directions, will, in a few years, have to fight for existence. It is even doubtful if the present policy of electrifying road tramways at great expense and inconvenience will be pursued. In view of the progress which has been made in the development of the motor-bus, it is believed in Great Britain that in future a large portion of the passenger traffic will be carried by these means, and that the policy of laying tram lines and incurring the heavy expense incident to installing the conduit or trolley system will be saved.

Another development in the dealing with traffic may be seen in south London, where the London United Electric Tramways Company has laid a network of lines. The presiding genius (the word is used advisedly) is Mr. J. Clifton Robinson, who assisted George Francis Train in laying the initial tramway in Europe forty-five years ago, and since then has become known as the director of the pioneer system of cable and electric tramways at San Francisco and Los Angeles. He has revolutionized south London, and now has under his control nearly eighty miles of tramways which bisect and intersect the most beautiful parts of the south-western districts of London.

The magnificent cars of his company run through the beautiful Thames Valley to Hampton Court, flash through Twickenham to Richmond Bridge, or land the passenger as far west as Uxbridge. The result of Mr. Robinson's enterprise was seen in the second year of the working of the company, when, on the average, every man, woman and child in the suburbs touched by his system boarded the cars 126 times. While the electric tramway can be constructed only at great expense and is therefore held by some—

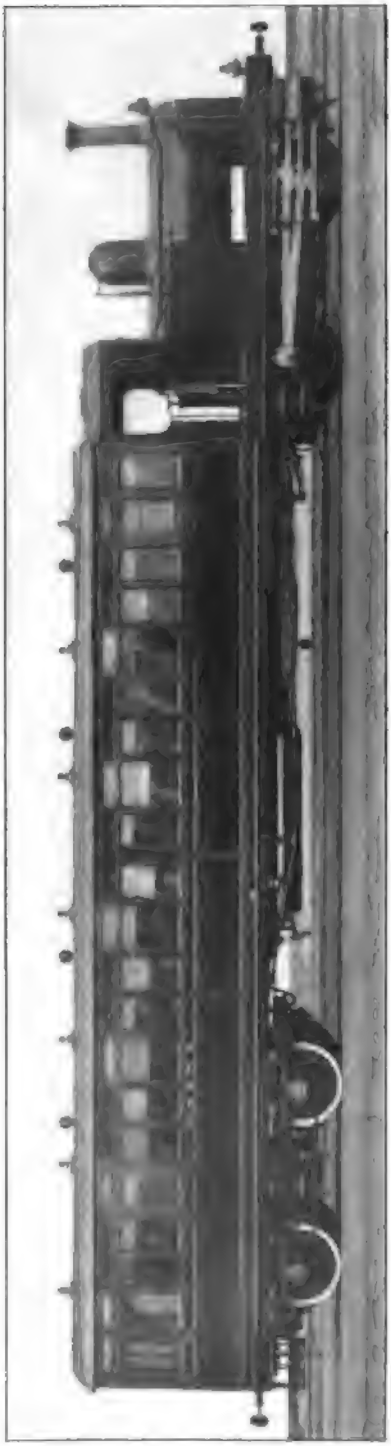
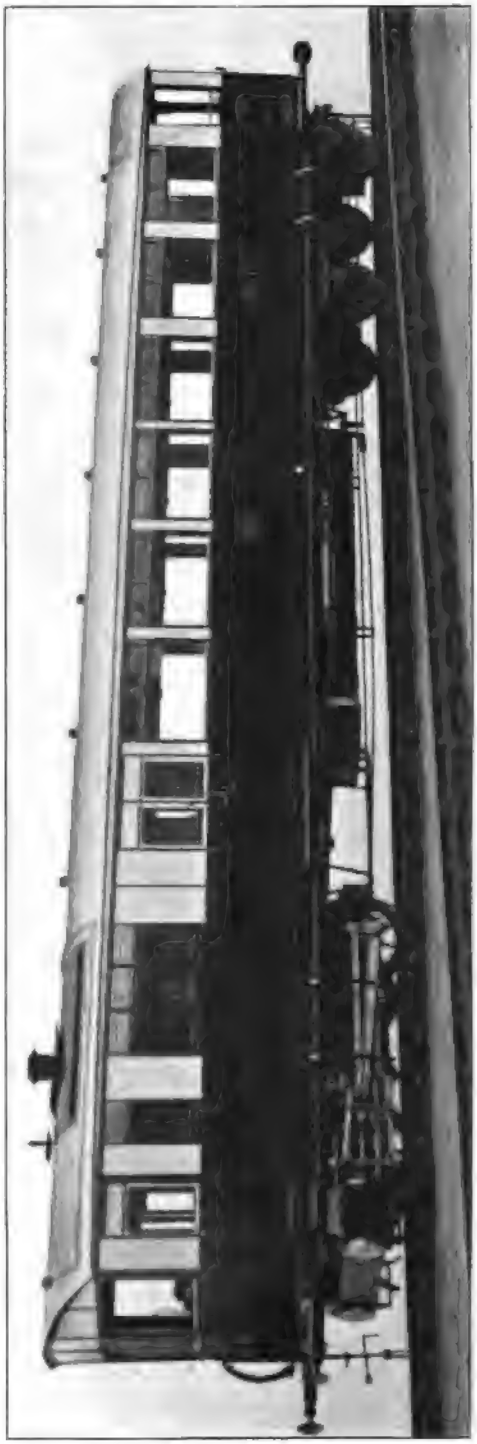


FIG. 13.—STEAM MOTOR-CARRIAGE WITH SEPARATE LOCOMOTIVE ON THE GLASGOW & SOUTH WESTERN RAILWAY. DESIGNED BY MR. JAMES MANSON, LOCOMOTIVE SUPERINTENDENT OF THE G. & S. W. R.



RAIL MOTOR CAR OF THE GREAT WESTERN RAILWAY CO., DESIGNED FOR LOCAL TRAFFIC CARRYING 52 PASSENGERS

though not by Mr. Robinson—to be unable to compete successfully with the motor-bus, the cost is nothing in comparison with that involved in the construction of a tube railway. Consequently travelling is cheap.

A workman can travel for five miles by tram for a penny, and in some cases as much as seven miles for one penny, and the average fare for the whole system works out at less than one farthing a mile. He is conveyed to and from his work with dispatch and even in luxury, for the cars closely resemble the best saloon carriages on British railways. When the line was opened, Mr. A. J. Balfour, the Prime Minister, prophesied that such means of quick transit would prove of immense importance in the solution of the problems created by the congestion of population within the inner circles of London.

As Cook brought within the means of the middle classes in Great Britain facilities for travelling all over the world, so the tramway is providing the poorest in London with facilities for enjoying a delightful day's holiday at nominal expense.

It is no exaggeration to say that Mr. Robinson has worked a revolution in London south of the Thames. The working man and his family on pleasure bent, who have exhausted the depths of Kew, may take a "round" ticket enabling them to make the "grande tour" through all that is most charming in the country lying to the south of London, where the advent of the cars has already led to an immense growth in the population, which is streaming outward from congested districts as quickly as houses can be built. In the great provincial towns, such as Bristol, Bournemouth, Plymouth, and Portsmouth, enterprise on the same lines is being shown, and the popularity of the double-decked cars has been signally proved.

A further interesting development which was first seen in provincial towns is the small self-contained motor-train for dealing with local traffic between the great centres of population and the outlying suburbs. Throughout Great Britain tramways and light railways have been introduced in the past few years, and as these competitors have invaded districts served by the existing railway companies, the latter corporations have had to cast around for some means for meeting the rivalry. Without exception the upward tendency of railway passenger receipts was checked by the rivalry of trams and light railways in urban districts, and in many cases the falling-off in revenue was most serious.

How this competition was to be met was the problem that faced the railway managers. A solution has been found in the self-contained motor train. The claim to the honour of being the pioneer in this direction is disputed, but among the first to adopt the new system of dealing with local traffic was Mr. J. C. Inglis, a well-known engineer and the general manager of the Great Western Railway, one of the greatest corporations in Great Britain.

In Plymouth, Swansea, and elsewhere the trams were robbing the line of its local traffic, but the motor-train has worked a revolution. The type of car varies, but the general character of the most popular makes now in use in Great Britain may be seen from some of the accompanying illustrations. The essential principle is that small self-contained trams can be run frequently between towns and suburbs at small cost. Such services are profitable as feeders to the main line of a system where an ordinary train would result in heavy loss, and in order to tap new intermediate districts small stations or "haltes" have been provided at slight expense so that every one living in the suburbs of towns to which the motor train has been introduced has a station practically within stone's throw of his home. See Page 513.

The success of the motor-train has led to a great development in coun-

try districts of the motor-omnibus and motor-lorry for the conveyance of passengers and market produce, respectively, to the nearest railway station, and by this means the Great Western Company, in particular, has encouraged a most promising field of excursion traffic, and assisted the small farmer in bringing his goods to the market. These innovations have proved a success from both a social and financial point of view. Mr. Charles Aldington, of the Great Western Company, has explained that in some parts of the country county councils have effectively seconded the efforts of the company by delegating skilled lecturers to demonstrate to farmers' wives and daughters the virtues of cleanliness in buttermaking, care in preparing poultry for the table, and neatness in packing.

While the promotion of a "light railway" scheme involves months of careful preparation and inquiry on the part of controlling authorities before beginning to carry out the works, a motor service can be started at the shortest notice along those natural arteries—the King's highways. A good motor service is as flexible as an elephant's trunk, and as capable of picking up things both small and large. It will flourish on crumbs that a self-respecting railway would despise, and a combination service of motor-omnibus and motor lorry will sweep up from the country-side traffic ranging from a load of broccoli to a cyclist with a punctured tire.

One benefit conferred by motor service is that manufacturers are enabled to utilize cheap and suitable sites for factories, the motor-lorry keeping them in touch with the gathering and distribution systems of the country. Apart from the purely commercial advantages of the public service motor-vehicle, there is a legitimate sphere of operation for the motor-car in conjunction with railway holiday traffic. Railway companies vie with one another in advertising the most attractive holiday resorts for the multitudes, and what more bracing pleasure can be desired than a trip on a smart motor observation car through the beauties of South Devon, over the rugged moors or along the wild coast to Land's End—inferentially bringing grist to the railway mill in the price of a tourist ticket from London, the Midlands, or the North, while this holiday element benefits the locality favoured by the tourist.

For water use, there are motor boats and launches built to suit lake, river and salt water work, and it will be possible by means of these to open up new and charming rounds of travel for the tourist, who is always seeking new ground; and the brain of the general manager of the Great Western Railway Company has conceived a future for motor boats in resuscitating the fortunes of some of the many dormant canals of the country.

So far as passenger travel is concerned, the petrol engine is generally considered the most suitable, and the whole of the Great Western Company's cars are of this type, with the exception of three steam cars at Wolverhampton. The bodies of the cars used by the different companies who have embarked on his "feeder" system are of different types, designed to accommodate various classes of traffic.

1.—Open observation cars, carrying 24 passengers, for summer pleasure traffic.

2.—Closed omnibuses, with roofs strong enough to take 15 cwts. of luggage, parcels, or goods, and seating 18 passengers.

3.—Double-decked omnibuses, of the type familiar in London streets, carrying 36 passengers.

4.—Open wagonettes, seating 22 passengers, and fitted with luggage roof.

5.—Composite bodies, seating 12 passengers inside, with a compartment available for luggage, mails, or goods, or for passengers desiring to

smoke. By these methods those who cater for public service in town and country in Great Britain are competing for custom and bringing the railway within easy reach of the most attractive villages and the public are gaining the advantage, while experience has already proved that good dividends are to be earned by the tram, bus, and railway companies. Competition is the soul of a commercial community. The rivalry has only recently begun, and those who are looking on, and see perhaps most of the game, appreciate that the contest between the various forms of locomotion is destined to become increasingly severe.

SEEING BY ELECTRICITY

By William Maver, Jr.

ALMOST simultaneously from two different places in the United States the invention of a device for seeing at a distance by electrical means is announced by two different inventors. Somewhat strange to say, the name adopted by each inventor for his device is "Televue." The names of the two inventors are J. B. Fowler and William H. Thompson.

A non-technical description of Mr. Fowler's device in one of the electrical papers shows a woman speaking into a telephone transmitter, while at the side of the transmitter is a projection akin to that of a hand stereoscope. The idea is that the apparition of the person at the distant end of the wire will be seen within this projection. It is said that four wires are at present required to accomplish the speaking and seeing, but that eventually two wires only will be necessary. It is also said that natural colours are reproduced in the apparatus. Complete details of the operation of this interesting apparatus are withheld, it is said, for certain reasons connected with Patent Office matters. In the meantime, however, it is reported that a company has been organized to push the scheme, and stock in the company will be offered to the public.

Mr. Thompson does not appear to have progressed so far with his invention as Mr. Fowler, but it is stated on Mr. Thompson's behalf that his device will be an improvement on the other one.

In the absence of details it is obvious that no opinion can be expressed as to the value of the claims of these gentlemen. It is well established that the problem which they have set out to solve is not an easy one. Attempts without number have been made to solve it by men well equipped for the purpose, but thus far without success.

Not long ago M. A. Nisco, of Belgium, made a careful study of many of the methods that have been proposed for seeing at a distance electrically, and concluded that none of the devices thus far experimented with possesses the necessary requirements for successful operation.

In the majority of the methods for transmitting sight to a distance, that property of selenium by which its electrical resistance varies with the intensity of the light thrown upon it, has been employed, but the use of this substance for this purpose has not hitherto met the expectations of inventors.

As a result of Mr. Nisco's study of the subject, he believes that a system constructed somewhat as follows would give practical results:—

Let a sensitive screen be prepared by coating a metallic net with an insulating varnish. Into the meshes of the net copper wires are inserted before the insulating material hardens. The surface is then filed off smooth and a coat of selenium is spread over the net, this forming a connection between the net and the copper wires. The selenium is then treated in such a manner as to crystallize it, which brings it into the required sensitive condition.

The copper wires are led into a hollow ebonite cylinder and are then brought to the outer surface of the cylinder through holes that are arranged to correspond to the position of the copper wires in the netting. The holes are arranged in spirals around the cylinder, and a steel blade is caused to pass around the cylinder at the rate of 600 revolutions a minute. As it does so, the blade makes momentary contact with the protruding copper wires, ten times per second. The blade, the copper wires and the metallic screen are in an electric circuit with a battery and a telephone receiver. To this telephone is connected a minute microphone which repeats the variations of current that may be set up in the selenium circuit into the transmission line.

At the receiving station a second telephone receiver, by means of another suitably arranged microphone, repeats the variations of current into a local circuit, which is arranged to produce a spark, the luminosity of which depends on the strength of the current, which latter, in turn, varies directly with the intensity of illumination at the selenium screen at the transmission station.

The spark-gap is placed within a cylinder which is provided with slots arranged spirally around the cylinder in a manner corresponding to the arrangement of the copper wires in the transmitting cylinder. The slotted cylinder revolves in unison with the blade at the sending station.

If then, says Mr. Nisco, a picture be thrown upon the metallic screen while the apparatus at each station is operating synchronously, the light of each spark at the receiving station will be cast on a receiving screen in a manner capable of producing an illuminated image of the picture at the transmitting station. The method just described produces only variations in illumination, and it requires two wires, one for maintaining synchronism between the moving apparatus, the other for transmission of the variable currents.

While Mr. Nisco's plan thus outlined does credit to his ingenuity, its practicability appears rather problematical. It is not altogether unlikely, however, that Mr. Nisco's suggestions have formed, and will form, the basis of the efforts of numerous aspirants for fame and wealth in this direction. The public, however, should take all statements of successful accomplishments of this nature *cum grano salis.*

THE ADVANTAGES OF PURCHASED ELECTRIC POWER

By H. B. Gear

IT was not long after the establishment of the historic electric central station on Pearl Street, in the city of New York, that the owners of the new enterprise realized how advantageous it would be to themselves and to the proprietors of small shops to sell the electric current derived from the lighting dynamos for power purposes.

Mr. Edison, having put the incandescent lamp on a commercial basis, directed his attention to the development of the electric motor, which soon became a commercial article. It is a noteworthy fact, that many of the motors made according to Mr. Edison's design are still in operation, having given reliable and satisfactory service for upward of fifteen years.

The small manufacturer was not slow to recognize the superiority of this new form of motive power, over the small steam or gas engine then in general use. The prospect of freedom from the heat and dirt incident to a small power plant and the possibility of locating shops on upper floors at reduced rental was very alluring, and the electric motor was soon started on its way as a revolutionizer of small manufacturing establishments.

With the establishment of central stations in other cities the movement became one of wide extent, increasing year by year and soon spreading to Great Britain and the Continent. In the decade from 1886 to 1896, the movement was mostly confined to those establishments whose requirements did not exceed 15 to 20 H. P.

In a description of central station developments in one of the largest American cities, which appeared in an electrical journal in the year 1896, a writer pointed with pride to the fact that the company's power business was growing rapidly, and that they had one customer whose motor installation aggregated 110 H. P., a single unit being as large as 20 H. P. To-day, in the same city, a 100-H. P. installation excites no comment, and this same central station company supplies half a dozen motor installations which aggregate upward of 1000 H. P.

Ten years ago the consumption of current for power purposes was only 28 per cent. of that used for lighting, while it is now 60 per cent. The rate of increase has been more rapid in the last few years than in the early part of the decade, and is keeping pace with the growth of electric lighting very evenly.

The reasons for this rapid increase in the rate of growth of electric power consumption during recent years are various, but there are perhaps three which may be considered most influential:—

1. The gradual reduction of the rates of charge made by central stations for electric power.

2. An increasing appreciation on the part of power consumers of the advantages of central station power, available at all hours.

3. An enormous expansion of power consumption generally, in which electric power has enjoyed the lion's share.

The rapid growth of the central station industry has resulted in equally rapid increases in the size of generating plants. This, in turn, has brought reduced generating costs and reduced selling prices. The reduced

selling prices are also largely the result of a system of charging devised by Wright, in Great Britain, and known among the fraternity as the "Wright Demand" system of charging. It is a differential system and is sometimes called the "differential rate." The basis of the system is the provision of a higher rate for a portion of the power used, and a lower rate for the remainder.

The object of the "high-rate portion" is to reimburse the producer for the fixed charges on the investment made for the consumer's benefit. As fixed charges go on the same whether power is used two hours or ten hours each day, the high rate applies to the current used during the first hour of each day. The current used during the succeeding hours is charged at the low rate, since this portion covers only operating expenses which are less than the fixed charges. This system is obviously most advantageous to the long-hour user, and has lowered the rates to a large class of power consumers who operate their plants from eight to fifteen hours, or more, a day. There are other modifications of the Wright system which are established upon the same basis, and differ only in the details of arrangement of high and low-rate portions.

The "differential rate" has been the basis of some criticism on the part of those who have imperfectly understood its working, but it is daily becoming more generally recognized as the only system which gives all consumers the same rate under the same conditions. The long-hour user of a small amount of power on the dif-

FIG. 1.—A STEEL BEAM SAW DRIVEN BY A 75 H. P. ELECTRIC MOTOR

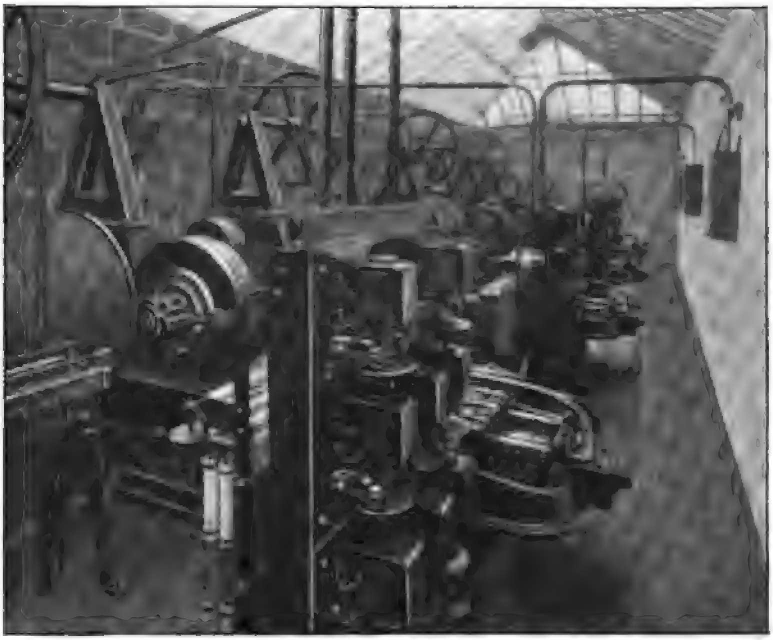


FIG. 2.—A BANK OF ELECTRIC ELEVATORS IN A DEPARTMENT SHOP

ferential rate is entitled to and receives his electricity at a low net rate, and this system has proven more attractive to small power users. The rate having been made such that it was possible for the power producer to become the power consumer at approximately the same or less cost, the other advantages of purchased electric power have given impetus to the movement.

The availability of a source of power which could be used in all, or a portion of, the plant at any hour of the day or night, allowing overtime operation in departments which may get behind, or in the plant as a whole during the rush season, freedom from care and responsibility of maintaining and operating a boiler and engine plant have been potent factors in inducing individual power producers to discard their power-producing equipment and become consumers of purchased power.

Other incidental advantages which have accrued to consumers of purchased power, in the larger cities particularly, are immunity from prosecutions for violation of smoke ordinances, freedom from trouble with coal supply during strikes, and in some cases relief from very costly interruptions of power supply, due to breakdowns in the power plant, which required a shut-down of a week or even a month's duration, to make repairs.

The campaign of solicitation which has been conducted by the central stations during recent years has been no small factor in bringing the advantages of purchased power before the general public and thereby increasing their appreciation of its value to them. The unexampled prosperity of recent years has been attended by an equally great expansion of the use of power for all purposes. Nearly all lines of manufacture require power, and the expansion of business necessarily means the expansion of power consumption.

The use of purchased electric power has increased more rapidly than the rate of power consumption

FIG. 3.—A PRINTING AND ENGRAVING PLANT WITH INDIVIDUAL MOTOR DRIVE

as a whole. This has been the result of causes other than the reduced cost and greater conveniences above mentioned, causes peculiar to electric power and to the central station system of supply. The application of the electric motor to individual machines or groups of machines has made a great saving in power requirements, owing to the reduction in the amount of transmission belting and bearing friction which are eliminated by the introduction of the individual drive, the electric transmission being much more efficient than any form of mechanical transmission.

In some large establishments several small steam plants have been replaced by one electric plant, from which power is being transmitted by wire to the various departments and buildings, the load being smaller than the sum of the loads of the plants removed and the power being generated more cheaply. But in other large plants and in the majority of smaller ones, the investment for the new electric plant has been saved by the introduction of purchased power, which has relieved the consumer of the care of power-producing equipment of any sort and has not tied up capital needed elsewhere in the conduct of his business. He has thus been able to procure his power at a smaller expenditure of capital, and, at the same time, to operate his plant at a saving over the old system of belt transmission and small engines.

Nearly all classes of power consumers have been benefited by being able to purchase central station power, but there is one which has been particularly helped, namely, that class whose power consumption is of an intermittent character, being used for such machinery as cranes, hoists, elevators, saws, punches and other machinery which consumes a considerable amount of power for a few seconds at a time, but whose total consumption is relatively small.

The user of this kind of power re-

quires a plant of excessive size to supply the sudden demands of his machinery, and his plant must operate at a small fraction of its capacity most of the time. The efficiency of production is, therefore, very low, and the cost of the power delivered is excessive. With purchased power, on the contrary, the consumption of power is reduced more nearly to that actually used, as the efficiency of motors at small loads is better than that of a steam plant, and most of the losses due to light-load operation in a steam plant are saved.

The machinery illustrated in Figs. 1 and 2 is of the intermittent type. Fig. 1 illustrates a cold-steel beam saw, which consumes a little under 10 H. P. while not sawing, but while sawing a steel beam, consumes from 60 to 80 H. P. The sawing operation lasts from twenty to thirty seconds, and the next cut is not made until after three to five minues have elapsed.

Fig. 2 illustrates a bank of electric elevators in a large retail shop, which is typical of a large class of intermittent power. The operation of elevators by electric power is much less expensive than by any other form of power, and the intermittent demand makes operation from an isolated plant very unsatisfactory in most cases on account of the flickering of the lights. The central station, having a large generating capacity at the service of its consumers, does not feel the variation in load due to the saw or the elevator, and is, therefore, able to supply power to this class of consumers at practically the same rates that it charges for steady power. Indeed, it is found that the presence of a considerable amount of such machinery on a large system has the effect of giving the central station a fairly steady load.

The possibilities of cleanliness and freedom from shafting when the direct-connected individual motor drive is employed is well illustrated in Fig. 3. This is a printing and engraving establishment where the elimination of belting is especially desirable, and also where the electric motor has proven invaluable on account of the facility with which variable speeds may be obtained.

Other instances of machinery which is being supplied by purchased power are in the cases of,—

Blacksmiths and foundries, where a supply of air-blast is very conveniently obtained by means of electric power, as it is not in continuous use, and no power is being wasted while the blast is not needed.

Clothing manufacturing, in which groups of sewing machines, mounted on long tables, are conveniently driven by electric motors, the motors being suitably housed so that there is no possibility of garments being injured by dirt in any way.

Laundries, machine shops, all kinds of metal work, stone-cutting, woodworking, and a variety of other industries, in all of which the advantage of purchasing power instead of producing it in their own plants is appreciated.

The foregoing comments have been made with special reference to the development of the use of purchased power on a retail basis, that is, installations of less than 400 to 500 H. P.

This article would not be complete without some mention of the purchase of power on a wholesale basis. Power supplied on a wholesale basis first came into prominence through the electrical development of the power of Niagara Falls, made available for use in the city of Buffalo and the vicinity in 1895. The central station company of Buffalo and the large manufacturing establishments having power requirements of 500 H. P. or more became purchasers of electric power from the Niagara Falls Power Company, abandoning their power-producing plants. Beginning with an installation of 25,000 H. P. in 1895, the original Niagara plant has been extended and other plants have been added whose aggregate capacity will amount to upward

of 300,000 H. P. if the plans of their promotors are carried out. This power will practically all be sold in wholesale lots to manufacturers who are establishing their plants in the vicinity of Niagara Falls, to central station companies, and to street railways in Toronto, Buffalo, Syracuse, Rochester and other cities within a radius of 150 miles of Niagara Falls.

The low cost of power generated by a waterfall is, of course, the prime reason for this tremendous development. A parallel series of events has occurred in several other places throughout the Western portion of America, where large water powers have been available, and many central stations are purchasing their electric power from the water-power companies, and they, in turn, retail it through their distributing systems.

The wholesale delivery of power has, however, been by no means confined to water-power plants. Large steam plants are furnishing energy to the lighting and traction companies and have sold power in wholesale quantities to each other in many cases. A central station company in Chicago is now supplying current for one of the elevated railways, and for the surface lines in wholesale quantities, these companies having abandoned the use of their steam plants except for a short period each day.

Other consumers, such as some of the large retail shops and newspapers, whose power requirements exceed 1000 H. P., should also be classed as wholesale power consumers.

Several large manufacturing establishments have within the last year found it to their advantage to use purchased power, either in part or entirely in their plants. A number of these have motor installations aggregating between 2000 and 3500 H. P. Indeed, it seems a fair statement that the use of purchased power is yet in a preliminary stage, and it is not saying too much to predict that the expansion of the use of purchased power, both in wholesale and retail quantities, will far exceed in the next five years that of the five years just passed.

SOME PRINCIPLES OF SOUND ENGINEERING

FOR THE INVENTOR

By Thorburn Reid

Mr. Reid's article is, in a measure, supplemental to the one entitled "Exploiting an Invention," printed in the May and June numbers of this magazine. It excellently illuminates the danger points upon which a good invention may come to grief unless guided by good engineering and business sense.—THE EDITOR.

FEW engineers who may have been associated with inventors in the making and developing of their inventions would be willing to concede to them or their methods any of the properties of sound engineering. On the contrary, such engineers are apt to become explosive when the inventor's engineering ability is mentioned.

That inventors are not primarily engineers is doubtless true, but it is a question whether their effectiveness would not be lessened in most cases if methods of sound commercial engineering governed their efforts. There are rare cases of inventors who are also good practical engineers, but these are the exceptions that prove the rule.

It is, however, possible to include the work of invention in the class of engineering by expanding the limits of that class to include it, and by applying to invention the principles by which it ought to be governed, principles which would differentiate its field from that of other branches of engineering, and would limit the activities of the inventor within that field.

The qualities of mind and the methods of thought of the successful inventor are almost diametrically opposed to those needed by the successful commercial engineer. The essence of invention is newness or, as the patent phraseology puts it, "novelty."

The inventor must do something that has not been done before or must do an old thing in a new way; the commercial engineer, as a rule, follows precedent.

When a problem that is outside of his own experience confronts the engineer, he must try to find out how others have successfully solved it and follow their methods. Except in those rare cases where there is no precedent to guide him, or when the precedents are not numerous enough to establish a uniform standard, the sound engineer will try experiments in commercial work only when the conditions absolutely demand them, or where the success of the experiment means a great gain and its failure can be easily remedied.

The inventor risks failure in the hope of achieving a great success; the commercial engineer takes no risk he can avoid, even though there be a possibility that by taking the risk he may greatly benefit his undertaking.

This does not mean that the commercial engineer may not take risks when the conditions demand them, but that his constant aim should be to accomplish the object sought by machinery and methods that have been standardized by long use, or whose efficacy has been proved in his own experience or in that of others. When, as sometimes happens, he is confronted by conditions that are so new or unusual that the employment of new or untried machinery or methods is unavoidable, it becomes necessary for him to proceed with the greatest care and, if he is wise, he will throw the responsibility back on

his employers by informing them of the risk necessarily involved.

The typical inventor has never any doubt of the success of his invention. Failures mean to him but temporary discouragement; he soon forgets them and remembers only his successes. It is perhaps fortunate for the progress of humanity that this is so, for without his enthusiasm, his contempt for obstacles, his sublime confidence and resilience in the face of failures and discouragements, the inventor would never succeed in obtaining the capital necessary to carry out his ideas, and consequently many of the most valuable inventions would probably never have been developed.

The typical inventor is a creature of fancies, imaginative, enthusiastic, a dreamer nearly always. He belongs in the class of artists, poets, and painters. He is impractical, irresponsible, but often lovable. Like others of his class, his temperament is apt to make him irritable, impatient of restraint, control or opposition. The peculiar conditions under which his art must be practiced, combined with his artistic temperament, often produce in him a state of chronic suspicion of the motives and actions of those with whom he is forced to work. He is incapable of understanding the conservative methods of thought of the commercial engineer or business man and places upon himself and his inventions too high an estimate of value. He has no sense of proportion with regard to the value of money, but dreams of millions with lofty assurance when he may not have enough to buy himself food withal, and gives away his last shilling or, it may be, some one else's, with sublime confidence that God will care for his own.

That the inventor, by reason of these qualities, often falls prey to an unscrupulous promoter or business man is an undoubted fact, but it is also true that many who can ill afford the loss of their savings frequently become victims of the inventor's over-confidence, lack of business judgment, and general irresponsibility in money matters. There is a right way of developing inventions, which is seldom the inventor's way, and the right method may properly take its place as a branch of sound engineering.

It has been said, inventions are out of place in commercial engineering. Their development should be considered as a separate undertaking whose sole object is to determine their value. eliminate practical defects and learn by experience the best way to make and apply them, and those who furnish the money for this purpose should understand clearly the risk they run.

Before such an undertaking is entered upon, it should be ascertained what demand there will be for the invention, what it will cost to make it commercially, whether or not there is any other device already on the market which will serve the same purpose as efficiently and as cheaply and what the probable profits will be.

The patent situation should also be carefully looked into with the help of a good patent expert to determine the value and strength of the patent, the possibility of infringement, the steps to be taken to prove priority of invention and for obtaining patents in foreign countries.

Then a careful and liberal estimate should be made of the probable cost of developing the invention and placing it on the market. It is usually disastrous to start into developing an invention without sufficient resources to carry the undertaking through to a successful issue.

When these preliminaries have been satisfactorily arranged, the work of actual development begins. At this point it is essential that the methods of the commercial engineer should replace those of the inventor if the work is to be carried to a successful conclusion at a reasonable cost.

The first step, then, is to make working drawings of the mechanism which is to embody the invention, and it is important that during this

process the principle of following precedent be held to as far as possible. Usually some operations involved in the working of the mechanism will be new and untried. Often a simple experiment by means of an inexpensive model will furnish the information desired, and even if the making of such an experiment involves considerable expense, it is usually better to make it rather than to take the risk of completing the whole machine and finding it a failure because some one of its minor parts does not function properly.

Every detail of the completed machine must be clearly and completely shown in the drawings before any shopwork is begun. The inventor's impatience to see his invention in actual operation will often prompt him to hurry the drawings into the shop, trusting to luck or his inventive ability to work out this or that detail during construction.

Such a course is seldom, if ever, admissible. It is always cheaper to work out details with a pencil on paper than with steel and iron in the shop, and there is never any certainty that the design of some apparently unimportant detail may not affect the design of many, if not all, of the remaining parts of the mechanism.

Most of us have heard of the man with the great invention almost completed and lacking the working-out of one minor detail, and many have learned to their cost that the lack of just this one detail was fatal to the success of the invention. In fact, so often is this true that of all the inventions that might pass successfully through the preliminary stages, only a very small fraction would ever get by the drawing board if the principles of sound engineering were followed at that stage.

The inventor is an idealist and is seldom willing to let well enough alone. As the drawings progress, he sees ways of improving the invention, ways often involving radical changes in the design and the throwing away of most, if not all, of the work already done. If the new design is adopted, it will not be long before he will repeat the procedure and will continue to repeat it, thus frittering away time and money without making any real progress toward the end in view. If the original invention has sufficient value to warrant undertaking its development, it is better to work out its design to completion and thus obtain a comprehensive knowledge of the difficulties to be overcome and of the means of overcoming them rather than to attempt improvements that will almost certainly involve difficulties as great as, if not greater than, those sought to be overcome. "Rather bear the ills we have than fly to others that we know not of."

Again, the inventive mind wants perfection regardless of cost. Sound engineering, on the other hand, nearly always involves a compromise. Cost must be considered at every stage as well as the practical conditions under which the mechanism will be used.

One of the most important, and usually least considered, elements in the operation of any machine is the human element. Somewhere in the operation brains and brawn must be used, and the brain is often of a low order of intelligence, and the brawn clumsy and uncouth. An expression often used among engineers is that the machine should be "fool proof." It is a common mistake of inventors to design delicate and easily deranged machines to be operated by men of little intelligence or with little or no experience in operating machinery of any kind, while the commercial engineer often feels constrained to fall short of perfection in order to meet practical conditions of this character.

The inventor is not interested in the process of developing his invention for practical use, except in so far as the problems arising in this process involve further invention. His pleasure lies in attacking new

problems and devising means of solving them. It requires more effort for them to apply their powers of mind to the tedious details required to make their inventions practical than most of them can be made to exert. Woe betide the man of money who depends on the inventor for this class of service, for he will wear out his soul in the disheartening struggle to get down to practical results.

The inventor, prolific of promises and predictions, will offer him bright and alluring pictures of the wonderful things he is going to do, each picture fading into oblivion, to be followed by another even brighter until in despair of ever attaining definite results the investor either pockets his loss and drops the whole enterprise in disgust, or does what he should have done at the start,—engages an experienced engineer to winnow the wheat from the chaff and prepare for the market the valuable grains that remain.

From all that has been said so far it is not to be inferred either that every inventor possesses all the qualities attributed to the typical inventor or that the inventive genius has not a well-recognized and valuable function in the material advancement of the human race. A few inventors are perfectly capable of developing and perfecting their own inventions without outside assistance. These are men of strength of will and self-control, who curb their genius within the bounds necessary for carrying one project to completion before starting another. But the very necessity for such stern self-restraint is in itself an evidence of the existence in their temperamental make-up of the qualities attributed to the typical inventor which it is necessary for them to repress.

The drawing of the machine having been completed and sent into the shop, the actual work of construction is begun and carried forward to completion. Here, again, as he sees his ideas wrought in material form, the inventor will see room for numerous improvements, ways in which certain things could have been better done; but unless some serious or fatal mistake appears that was overlooked in the drawings, the original plan should be adhered to even at an increased expenditure of time and money, or at the expense of decreased effectiveness or even of partial failure. The machine should be completed and tested as a whole, so as to determine as many of its faults and defects as possible, and at once, rather than to throw away much, if not all, of the work already done in the effort to remedy some minor defect and quite possibly introduce a remedy worse than the disease.

When the machine has been completed, a test invariably reveals defects hitherto unsuspected, no matter how carefully the preliminary work has been done, and only too often it is a flat failure by reason of some fact brought to light by the test, which was entirely unforeseen and without remedy.

If only minor and remediable defects are thus shown, it is wise to remedy them in the existing machine with as little change as possible rather than to immediately begin the construction of a second machine. In a word, it is well to complete one machine that will accomplish the result sought, even though imperfectly and inefficiently, and test that machine thoroughly, so as to discover its efficiency, its capacity, and its limitations. With the knowledge thus gained, the second machine will be far nearer perfection than by trying to remedy piecemeal the defects disclosed during construction only.

When now the invention has been developed into practical, commercial shape, a multitude of engineering and commercial questions arise as to the best methods of manufacturing and marketing the machine, questions to which the answers depend on the capital available, the nature of the market for the invention, the state of the industry, whether split

up into numerous small concerns or dominated by one or more very large ones, or whether a demand already exists or must be created. The list of things to be considered at this stage could be indefinitely extended, but the important principle to be noted is that such questions should not be left to be settled by the inventor, but by a commercial engineer of sound common sense and extended experience, preferably with the assistance of a business man of experience and ability.

From its very nature and by reason of its value in its true field, the inventive mind is unfitted to rightly decide such practical details, and working them out is usually such drudgery to the inventor that he will not give them the attention they must receive if errors and extravagances are to be avoided.

The true inventor can no more help inventing than a moth can help flying into the flame. He will seek to change methods representing the crystallized experience of many decades, with perfect confidence in his conclusions, although his experience with the methods in question and his knowledge of the history of their development may be practically nil. If, therefore, he is placed in charge of the manufacture of his machines for the market, he will seek to overturn existing shop methods, thus creating confusion, reduced efficiency and increased cost, and will be continually seeing new ways of improving his invention, as he thinks, most of which will be found impractical or detrimental, and all of which will involve delay and confusion that he can, only with great difficulty, be persuaded to consider of any importance.

System and fixed routine are the very breath of life in a commercial machine shop, essential to the efficient and economical progress of manufacture; but these essentials are foreign to the inventive mind.

From this stage onward, in fact, the inventor's activities should be confined mainly to suggestions to be adopted or not, as the commercial engineer may deem advisable, or to the making of new inventions. Any new inventions that he may make, however, should be developed and tested in precisely the same way as the original one before they are placed on the market. It is suicidal to send them out to the customers before they have been tested to determine whether or not they will work properly and to eliminate defects. On no account should customers have such experiments tried upon them, as such a course is likely to lead to refusal of payments or damage suits, as well as loss of customers and of reputation.

The inventor's activities should also not be allowed to get in the way of commercial work, and clog manufacture. Whatever shop work is required for models, experiments, etc., should be considered as subsidiary to the commercial work, and be ordered so as to derange the regular routine of manufacture as little as possible. It must be kept in mind that the making of profits or dividends is now of prime importance, while the new invention can wait; and often the opportunity thus afforded the inventor for deliberation and sober second thought will reveal to him defects to be eliminated or of such a character that they may render the invention entirely valueless.

Most of what has been said above applies to the typical average inventor, with whom the engineer or investor most frequently comes into contact. The great inventive genius, while usually possessing the qualities ascribed to the typical inventor in a highly intensified form, will sometimes combine with these other qualities which are quite as valuable in placing him at his high eminence as those already mentioned.

The genius of this class often has what seems to the ordinary plodding engineer a marvellous, almost uncanny, ability to grasp compre-

hensively the action and reaction of a complicated piece of machinery, to predict the results of certain adjustments or changes, or to know beforehand and plan for all the conditions and requirements that must be met. This is, doubtless, due to his possession of a vivid and highly cultivated visual imagination that enables him to make a picture complete in every detail, and hold it with all its details clear and distinct in his mind's eye while the mechanism thus visualized performs its functions.

Occasionally an inventor may combine most of these qualities with sound business judgment or executive ability and knowledge of men, but such a combination is rare indeed, and the man who possesses it need scarcely set a bound to his ambition.

However, rules and principles are not to be used to fetter genius. The genius is a law unto himself, and will usually succeed in overriding and setting at naught the laws framed for his procedure by other men. The principles outlined in this article apply only to the average man of his class, and even then good judgment must be used in their application. No principles can be framed that will apply to all the circumstances that may be met with, and particular conditions may require bold treatment; but in the main these principles are partly the result of personal experience and partly of the combined experience and judgment of many others, and departure from them is a step to be taken only after careful consideration.

What has been said so far applies mainly to the development and application of an invention after it has been made and patented. There is little profit in attempting to lay down any general rules for, or describe the methods employed by, inventors in the process of inventing itself. Usually they do not know themselves how they arrive at an invention, and, in any case, their methods are instinctive, and, to a large extent, sub-conscious. Inventing is not a science, a profession, or a trade, but an art. The inventor is born, not made, and study and application can no more make into a successful inventor one who lacks the inventor's temperament than they can make a successful musician out of the man who lacks an ear for music, or a painter out of one who is colour-blind. As has been said, the true inventor cannot help inventing; it is part and parcel of his nature, and must find expression.

There is usually a time in the career of the young engineer when he gets the inventor's bee in his bonnet, and unless he has the divine spark of genius, it may go hard with him unless he quickly realizes his limitations. He is apt to cease to be of much value to his employer while the attack is upon him, and is even likely to become a nuisance to his associates and superiors by forcing upon their attention inventions in which they are not interested or whose defects it becomes necessary for them to point out.

Such attacks are often superinduced by a contemplation of the large rewards that sometimes come to inventors. They would, perhaps, not be so eager to try their 'prentice hands if they knew that where one inventor succeeds and gets his reward, a hundred fail and are forgotten; that when the invention has been made, even if it have great value, a long and weary road lies between the inventor and his goal. Money, much money, must be found with which to patent it, develop it, and place it on the market. Other inventions may supersede or have anticipated it, some feature of his invention may infringe some patent already in existence and its value be thus destroyed, some powerful corporation may steal it and rob him of his reward, or may wear him out with expensive patent litigation instituted for that purpose alone.

At its best, invention is but a form

of speculation; at its worst, a gamble. However, if the game must be played, some of the principles of sound engineering may be applied to it.

The inventor should know thoroughly the history of the art to which his invention belongs. The essence of invention is noveltv, and unless he knows what others have done he cannot know that his invention has not been anticipated and thus rendered valueless. This information is usually to be obtained only by the tedious drudgery of delving into the files of the patent office and of the technical journals, although in a few branches of industry text-books can be found that give a fairly comprehensive presentation of the history of the art.

He should know by personal observation and experience the present state of the art to which his invention pertains. Even a genius cannot expect, after a few hours' study of an art of which he previously knew little or nothing, to make a valuable advance in it when many other men, some of them probably equally as able as he, may have spent years of work and study at the same problems. By lacking such personal knowledge he will often be ignorant of some factor of the situation not clearly germane to his problem, but which indirectly affects it in such a manner as to render his efforts entirely abortive.

Another essential element of invention is utility, and strange as may seem the necessity of mentioning an element that seems so obvious, no one who has not had experience with them can imagine how many inventions have been made in which this element is lacking,—often even not considered at all.

He should establish the date of his invention by explaining it as clearly as may be to others who may serve as witnesses if the question of priority should ever arise. It is one of the most curious facts of both invention and science that two men at widely separated points, absolutely unconnected with each other, perhaps each ignorant of the other's existence, have often hit upon the same invention or new fact of science at almost the same time and under circumstances that made it impossible that either could have known of the other's discovery before he hit upon it.

There have been cases where the question of priority of invention has been a matter of days only, almost even of hours. The so-called "rotary field" patents are an interesting case in point. The scientific world has accepted without question the fact that Ferraris first discovered and disclosed the fundamental principle upon which the inventions covered by these patents are based; but simply because his disclosure was not so framed as to constitute legal evidence of priority in a court of law, Tesla was able to secure patents based on this principle which he disclosed some time later than did Ferraris, and these patents have been almost uniformly upheld by the courts.

The broad general principle of what may be called the inventive branch of engineering, then, is that invention is an art that requires in those who would practice it successfully certain rare and valuable qualities of mind which are only occasionally combined with sound commercial engineering or business judgment, and that, therefore, the inventor's activities should be confined to invention only, while the work of developing the inventions and placing them on the market should be delegated to commercial engineers and business men who possess the practical judgment that the inventor nearly always lacks.

It is not forgotten that commercial engineers in the regular course of their work sometimes devise new machines or methods that are patentable and valuable, but such cases are sporadic and more or less accidental, for it is almost invariably the case

that the work of the commercial engineer loses in value and efficiency by just so much as he directs his attention and efforts towards invention. It is, therefore, the part of wisdom for him to confine his attention to the solution of the problems in hand by sound engineering methods and consider inventions as a mere accidental by-product.

RENEWABLE RAIL HEADS

By William H. Booth

WHEN it is considered that a rail is worn out when it has lost about 5 or 6 per cent. of its weight, it becomes obvious that anything that will save even a portion of the rail must be very valuable. Tramway rails suffer more rapid loss than railway rails, because the gradients are steeper, there is a much greater proportion of braking, and the amount of grit that gets upon the rail is much greater. Everything tends to wear. The concealment of the fish plate bolts in the paving also prevents that prompt and periodical screwing up of the nuts that is essential to joint permanence. The rail ends of a tramway may become battered, and a rail may be thus worn out before it has lost even its 5 per cent. allowance of wear.

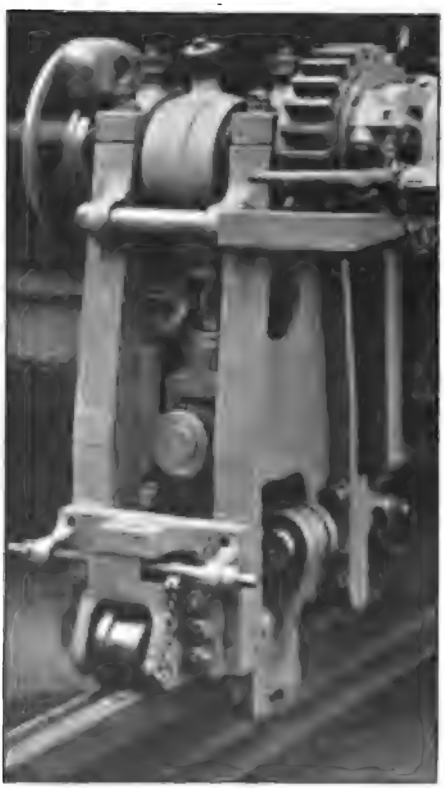


FIG. 1.—THIS MACHINE IS FOR CUTTING THE FLANGES OF OLD RENEWABLE HEADS

When worn out, the cost of new rails is not the only thing involved, for the old rails cannot be removed except by removing the paving on each side of the rail. The new rails must be laid and properly packed and grouted solidly upon the concrete bed and the paving must then be put back. A considerable move has recently been made in the way of renewable rail heads. The idea of a renewable head is excellent. The difficulty has been to carry it into practice. About the earliest system to come much into vogue was that known as Baker's. This compound rail consisted of short lengths of cast-iron ⊥ girders laid on a concrete foundation. The vertical web of the ⊥ was double, and in the middle deep space contained the vertical flange of the rolled steel **T** head. The vertical web was pierced for cotter wedges which passed through both the steel and the cast iron and

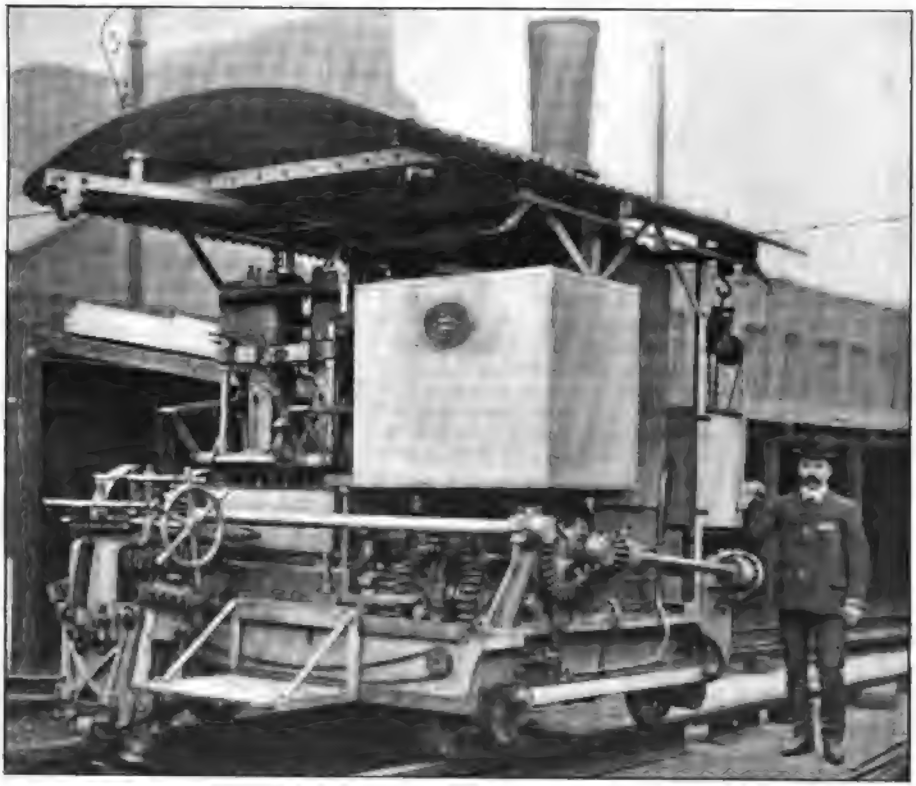


FIG. 2.—ROLLING ON A NEW RAIL HEAD AFTER THE SYSTEM OF THE ROMAPAC TRAMWAY CONSTRUCTION CO., LTD., LEEDS, ENGLAND

held the rail head in place. When worn out, the rail head could be released by removing the wedges or cotters and a new head could be inserted. It could always be arranged for the joint of the head piece to come upon one of the chairs so that joints were always supported. The system was laid down in Manchester, among other places, and was fairly satisfactory.

With the heavier cars of electric lines, however, something different is required. Loose rail heads, held down by bolts with dovetailed heads sunk in the bottom of the rail grooves, have the disadvantage that they do not hold the rail head centrally nor do they hold it continuously. A thin rail head is apt to be curled by the action of the rolling wheels.

In the case of the latest system of renewable head,—the Romapac, here illustrated,—the head of the rail is simply a channel bar with two comparatively thin vertical flanges and a heavy web, the web forming a stout rail head. The permanent rail, to which the top has to be attached, is an ordinary T rail with a small head. The vertical flanges of the renewable head fit closely on either side of the under rail head, and they are then rolled in laterally so as to clip this head tightly by means of pinching rollers carried upon and actuated by a special machine on carrier wheels. (See Fig. 4.)

This machine runs forward upon the evenly applied rail-heads and draws itself forward by the grip of the pinching rollers upon the side flanges to be rolled upon the head

FIG. 3.—A FRONT VIEW OF THE ROLLING-ON MACHINE

of the under rail. When worn out, the renewable head is milled along one lateral flange by a travelling machine, Fig. 1, and the flange is then bent back by a second machine and the head is set free and a fresh new head can at once be rolled on.

The advantages of this system are obvious. In the first place, the under rail remains permanent. Secondly, very little paving has to be removed when cutting away and renewing the head. Thirdly, the head can always break joint with the ends of the supporting rail body, and there can be no joint hammerings, for the top is rigidly held to the solid body of the under rail and cannot hammer under the wheels. The joints, again, of the under rails are bridged by the rail head, which, with its side flanges, possesses considerable rigidity of it-

self and effectively bridges the joint and prevents hammering. A track thus laid is therefore, to all intents, continuous. When worn out, the removal of the head signifies the rejection of a part only of the full weight of steel in a track and the saving thus effected, added to the saving in labour, paving, and concreting, is very great.

In the common system the renewal of a rail means also the renewal of the bonding connections, the cross bonding, and the cross ties which hold the rail to gauge. The total economy is, therefore, very considerable. It does not appear practicable to extend the system to points and to crossings and special work, but the abutting end of such work can be arranged to take the end of the rail head, which thus makes a rigid connection between the straight or ordinary rails and the special work, apart from the connection made by the fish plates. If such renewable heads will actually give the results which they promise to give, they will become the means of introducing the most serious economy in tramway maintenance that has been made since electric traction was introduced.

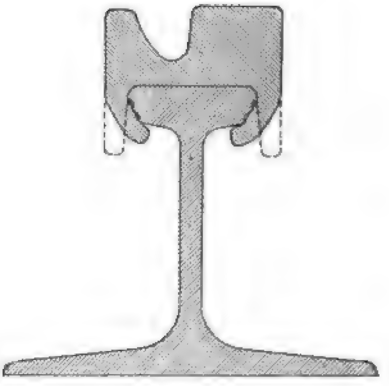


FIG. 4.—THE DOTTED LINES SHOW THE FLANGES OF THE TOP SECTION BEFORE HAVING BEEN ROLLED ON BY THE MACHINE

SPECIALIZATION IN MANUFACTURING

THE MEANS TO SUCCESS IN MODERN INDUSTRY

By Alexander E. Outerbridge, Jr.

Mr. Outerbridge starts with the assumption that nowhere has specialization in manufacturing been so thoroughly developed and so extensively employed as in America. Accordingly, America's remarkable growth is used by him to illustrate the splendid results of such specialization.—The Editor.

SPECIALIZATION is the key note of success in modern methods of economical production, and investigation shows that in all branches of manufacture specialization has been more thoroughly developed in America than elsewhere. This, taken in conjunction with the country's natural resources, i. e., its boundless wealth of raw material, accounts, in large measure, not only for its phenomenal prosperity, as shown in the enormous production and home consumption of manufactured products, but also in the amazing increase in exports of American manufactures especially during the past decade.

For the purpose of showing at a glance the extent of this growth, a few typical figures have been culled from the mass of statistics contained in the volumes of the twelfth census of the United States, selecting industries in which the value of the annual product exceeds one hundred million dollars.

The census of 1900 shows a valuation for iron and steel production exceeding $800,000,000 as compared with $430,000,000 in 1890, and a total valuation of iron and steel industries, including the products of foundries and machine shops, bolts, nuts, rivets, washers, forgings, nails and spikes, doors and shutters, pipe, architectural and ornamental ironwork, etc., of almost $1,800,000,000.

The value of the annual product of the boot and shoe factories exceeded $261,000,000, and the value of cotton goods exceeded $339,000,000. It is said that in 1900 more than three pairs of shoes were made in the factories for every man, woman and child in the United States.

The manufacture of clothing for men reached the astonishing figures of more than $415,000,000, and of women's clothing (factory product only), of more than $159,000,000 in 1900. The latter is a comparatively new industry.

The total annual value of industrial products as shown in the census of 1900 exceeded $13,000,000,000 as compared with less than $9,400,000,000 in 1890,—an increase of 38¾ per cent.

With respect to the value of products of domestic manufacture exported to foreign countries in the decade intervening between the eleventh and twelfth census reports still more remarkable relative gains appear. The value of the exports of iron and steel and manufactures thereof (excluding iron ores) in 1900, is shown to have been $122,000,000 as compared with $25,542,000 in 1890,—an increase of 377.3 per cent. The great bulk of these exports of iron and steel manufactures consisted of articles in which American producers have exhibited special skill.

The value of agricultural implements exported exceeded $16,000,000

according to the census of 1900 as compared with less than $3,900,000 in 1890,—an increase of 327 per cent. The latest reports show that American exports of agricultural machinery in 1905 (not including auxiliary machines used on farms and plantations) reached the sum of $22,124,132. The exports to Argentina alone were $5,733,615 as compared with $805,703 in 1900.

The most remarkable increase in exports is shown in the case of copper and its manufactures (excluding copper ores), viz., $58,000,000 in 1900 as compared with $2,350,000 in 1890. This phenomenal gain was caused by the increased use of copper for all kinds of electrical appliances in which America has taken the lead of the whole world, mainly through the perfection of methods of manufacture. A very recent announcement by the Director of the United States Census Bureau of the result of tabulation of statistics of copper smelting for the calendar year 1905, shows a remarkable increase as compared with 1900, as follows:—

	1905	1900	Per ct. of Inc're
Gross value of products Smelting and refining....	$240,780,216	$165,131,160	45.8

Having thus endeavoured to show by a few statistics the enormous strides that have been made in manufacturing in America, and having claimed at the outset that it is largely due to specialization in manufacturing, it is pertinent to ask specifically what is meant by this term?

Certain fundamental principles characterize American methods of manufacture, such as the employment of special machines to perform specific operations only whereby the output of a factory is enormously increased, minute and systematized sub-division of labour is effected, the costly work of finishing and adjusting is minimized, and the highest development of skill, accuracy and dispatch is acquired. These principles find their most efficient application in large establishments where, in many instances, hundreds or even thousands of repeated operations of the same kind are performed in rotation without material change of adjustment of the machines. As an illustration a case may be cited coming under the writer's observation, where the cost of machining a small bronze casting was reduced from 25 cents per single piece to 2 cents per piece in lots of 500.

Everyone is familiar with the enormous reduction that has been effected in the cost of making of clocks and watches in quantity by machinery as compared with hand work. A watch, guaranteed to keep good time, may now be bought at retail for less than the cost of having an expensive hand-made watch cleaned. In the large factories cheap watches are made in lots of a thousand at a time, and sold for less than $12 per dozen.

Some time ago the writer purchased a neat watch in a hardware store for 75 cents (the regular retail price) and found a printed guarantee of the factory on the inside of the case to repair the watch free of charge, if found not to keep good time and returned to the factory within one year, unless it bore evidence of having been maltreated. This watch has been keeping excellent time for some months without requiring any adjustment of the regulator. The original cost of this watch was less than one-fourth of the interest on the amount paid by the writer thirty years ago for a Swiss watch of fairly good make.

According to the statistics given in the Census Report of 1900, the annual output of watch movements from the factories in the United States was 1,825,769, and its value was $6,036,240, making the average value of the watch movements at the factory only $3.36.

It is undoubtedly true that the high wages paid to skilled labour in America have acted as a powerful stimulus to the invention and perfecting of labour-saving machinery, and the employment of such labour-

saving devices, operated by high-priced, intelligent mechanics, has resulted sometimes in a very much larger output and lower cost of product per man employed than anywhere in the world under old conditions. This accounts for the fact that America is able to compete in the markets of the world in manufactured articles of all kinds, notwithstanding that the wages paid are the highest in the world.

Specialization in manufacture means, in a word, that the manufacturer selects some product for which there is a good demand, or for which a large demand can be created by reducing the cost sufficiently to change its character from that of a luxury of the comparatively few people of wealth to a necessity of the many persons of moderate means. The manufacturer accomplishes these results by devoting his entire capital, energy and ability to the development of the trade, and the betterment of the methods or appliances of manufacture, so reducing the cost as to be in at least partial control of the business.

As an illustration, the manufacture of the metal aluminium may be cited. About twenty-five years ago the writer purchased a small quantity of this, then comparatively rare, metal at a cost of eight dollars a pound. About that time a young chemist, named Castner, devised a process for reducing aluminium from its oxide, using sodium as an intermediary, and showed that he could cut the cost of manufacture in half; a large plant was erected in England at an expense of about a quarter of a million dollars, but before the factory was in full operation an electrolytic method was brought out in America which did away with the use of sodium, and reduced the cost to a mere fraction of that of the Castner process, which latter was promptly discontinued.

The annual report of the United States Geological Survey for 1904, recently completed, shows that this industry dates its beginning from 1883, in which year the production was only 83 pounds. It was not until 1891 that the output reached 100,000 pounds, while the output in 1904 was 8,600,000 pounds. The present quoted price of the metal (over 99 per cent. pure) in ton lots is 35 cents a pound. Nearly all of the output in America comes from one establishment, located at Niagara Falls. With each successive reduction in price, new uses have been found for this metal.

In the foregoing illustrations the writer has endeavoured to show, first, the economy that has been effected in manufacturing where the same machinery and appliances are used, but the quantity is increased, and second, the difference in cost where an entirely new process is used. Innumerable examples of similar kind could be given, but the same principles would prevail in all.

One of the most recent advances noted by the writer is the rapidly growing substitution of machine-moulding for hand-moulding in foundries. As an example of what has been accomplished in this direction, two cases coming under his immediate notice, may be cited. Two green sand moulds, made from different patterns, which formerly cost \$1.06 each when made by hand, now cost 11 cents, and 20 cents each made on moulding machines; the cores for these moulds formerly cost, made by hand, 50 cents and 25 cents each; they now cost 11 cents and 3½ cents each made by machines. By hand one skilled moulder could make three of the moulds per day from either pattern. By machine one man,—an unskilled labourer,—makes 48 moulds from one pattern and 21 moulds from the other. In machine moulding the cost here given includes the wages of the machine operator, one helper and one crane operator, while in the former case the cost includes the moulder only.

It is stated that when Edison first made the small incandescent electric

lamps, consisting of a carbon filament fixed by platinum wires in a pear-shaped glass bulb from which the air had been exhausted, the cost was $3 each; now many million similar lamps of better quality are made every year and sold at less than 20 cents each.

There are, at times, dangers of overproduction in this modern system of specialization; nevertheless, it seems to be evident that the secret of success in manufacturing to-day lies largely in concentration of effort in developing the plant to the highest degree so that a superior product may be turned out at a minimum cost. This implies a complete modern equipment of machinery and modern methods of management.

It may be stated as a general proposition that if a new machine be invented which will, by increasing the output only 10 per cent., reduce the cost an equal amount, it pays to "scrap" the old machine. In many instances new machines have been invented which have reduced the cost of manufacture of a given article over 50 per cent. Some time ago a delegation of foreign workmen visited industrial establishments in America, and on their return home made a report in which they said:—

"The (American) manufacturers are unceasingly replacing old machinery by new types. * * * The rapidity of the machines is astonishing, and the development of specialization in manufacture in the United States seems to border on the marvelous."

They referred especially to improvements in the manufacture of agricultural machinery, and of boots and shoes, in which industries they "did not find a single machine out of date." The latter industry has been greatly specialized; there are separate factories engaged exclusively in making uppers, heels, insoles, linings, stiffenings, tips, clasps, strings, staples and a variety of other articles classed as "boot and shoe findings."

The substitution of machinery for hand labour in all industries has effected a radical change in the relations between capital and labour. Formerly there was a well-grounded belief that the employer objected to paying labour more than a certain fixed sum per day and the most efficient worker believed that it was to his advantage to conserve his efforts under the fear that increased efficiency on his part would result, sooner or later, in a cut in his wage-rate, so that in the future he would be compelled to work harder in order to obtain an equivalent amount of money.

Now, the wage earner tends a machine, the cost of which often represents an outlay of a large sum of money, and the interest on the investment sometimes largely exceeds the amount of his wages. It is, therefore, to the advantage of the employer to offer large inducements to the wage-earner,—in the way of "premium" or "bonus,"— to facilitate the operation of the costly machine, so that a maximum output may be secured. This does not mean necessarily overtaxing the strength of the operative, as strenuous labour on his part is, as a rule, not necessary to effect this result; but simply close attention to details is required in order to avoid waste of minutes in making necessary changes of adjustment of the machine.

An actual instance in point is that of two lathe hands working side by side on duplicate machines on the same class of work. One man is highly efficient and ambitious to earn large wages. The average output of good work from his lathe is twice that which is turned off from the lathe tended by a less skilful and less ambitious man. The actual manual labour performed by the efficient man is little greater than that of the inefficient man, but his wages are more than twice those of his companion, for he is worth more to his employer than are two inefficient lathe hands.

The writer would here submit to

the consideration of his readers a few thoughts on the ethical influences of invention of machinery and of modern methods of manufacture upon the wage-earning class, as many writers on such topics cling to the false notion that modern inventions and methods, while of supreme advantage to capital, are detrimental to labour, displacing many hands and generally lowering the intellectual status of the operative. The writer claims, from daily observation in large establishments, extending over a period of thirty years, in which the greatest changes have taken place, that exactly opposite results have accrued therefrom.

Every new successful machine or invention opens up new avenues of industry, often of vast extent, giving employment of new kind sometimes to hundreds of thousands of wage-earners.

Witness the introduction of electric power in all its innumerable applications, such as the telegraph, telephone, dynamos and motors, etc. Under old conditions of hand labour the lot of the wage-earner was hard and often degrading; he lived, as a rule, in poverty and squalour; the proportion of paupers to the self-sustaining, especially among the old and infirm, was vastly greater than it is to-day, for the average toiler could not then earn more than barely sufficient to support himself and his family during the period of his active life in the humblest manner, and very often, therefore, he became of necessity, a charge upon the community in his declining years. The old reports of the Poor Laws Commissioners, of England, more than sustain these assertions.

The Hon. Caroll D. Wright, formerly United States Commissioner of Labour, than whom there has been no more thorough student and investigator of such problems, says:—"The inevitable ethical result of the application of machinery has been to enable a man to secure a livelihood in less time than of old, and this is grand of itself, for it must be considered that as the time required to earn a living grows shorter, civilization advances, and that any system which requires all his time for the earning of a mere subsistence, must be demoralizing.

"In warm and comfortable clothing, in heating and lighting, and in a thousand ways, invention has brought with it more comfortable conditions, including health and longevity, the average of life being 10 per cent. higher than in olden time. * * * Under the old system,—the domestic system,—which was displaced when machinery came in and the factory system was established, the most demoralizing conditions prevailed. Goldsmith's 'Auburn,' and Crabbe's 'Village' do not reflect the truest conditions under the domestic system."

In conclusion, let us contrast for a moment still further the former status of wage earners with the prevailing social conditions of a similar class to-day. Formerly, compulsory education of children was unknown, and all members of a family were compelled to work from morning till night to provide the barest necessities of living. Twelve to 16 hours of daily labour prevailed at one period, and children of tender years were compelled to contribute their share of work to the common meal. We are told that an adult hand weaver could weave from 42 to 48 yards of common sheeting a week, working 12 to 14 hours a day; a weaver in a modern factory, tending six looms, can turn out 1500 yards a week, working 66 hours.

It is said that there was a time when a linen sheet represented 32 days of hand labour, and later that a spinner could turn off only 8 ounces of No. 10 cloth in 10 hours, or 3 pounds a week; the modern operator of the mule spinning machine can turn out over 3000 pounds in the same time, with far less toil.

Millions of wage earners have shared the advantages of the in-

creased unit of production per man, made possible by modern machinery and modern methods. Under the modern factory system, laws have been passed for the protection of workers. Compulsory education of children is the rule in civilized countries, and the evils of child labour have been lessened and will eventually be eradicated. The hours of labour have been shortened and the means of recreation increased. Indeed, in every way the condition of the wage-earning class has been improved.

It is a trite, but true, saying that we are living in an age of intense mental and physical activity in all industrial affairs. People are still living who witnessed the birth and growth of some of the most marvelous inventions and discoveries in methods of transportation, and of conveying intelligence to distant places; we are to-day observing the birth of even greater wonders, such as wireless telegraphy across the ocean, and other practical applications of Nature's laws.

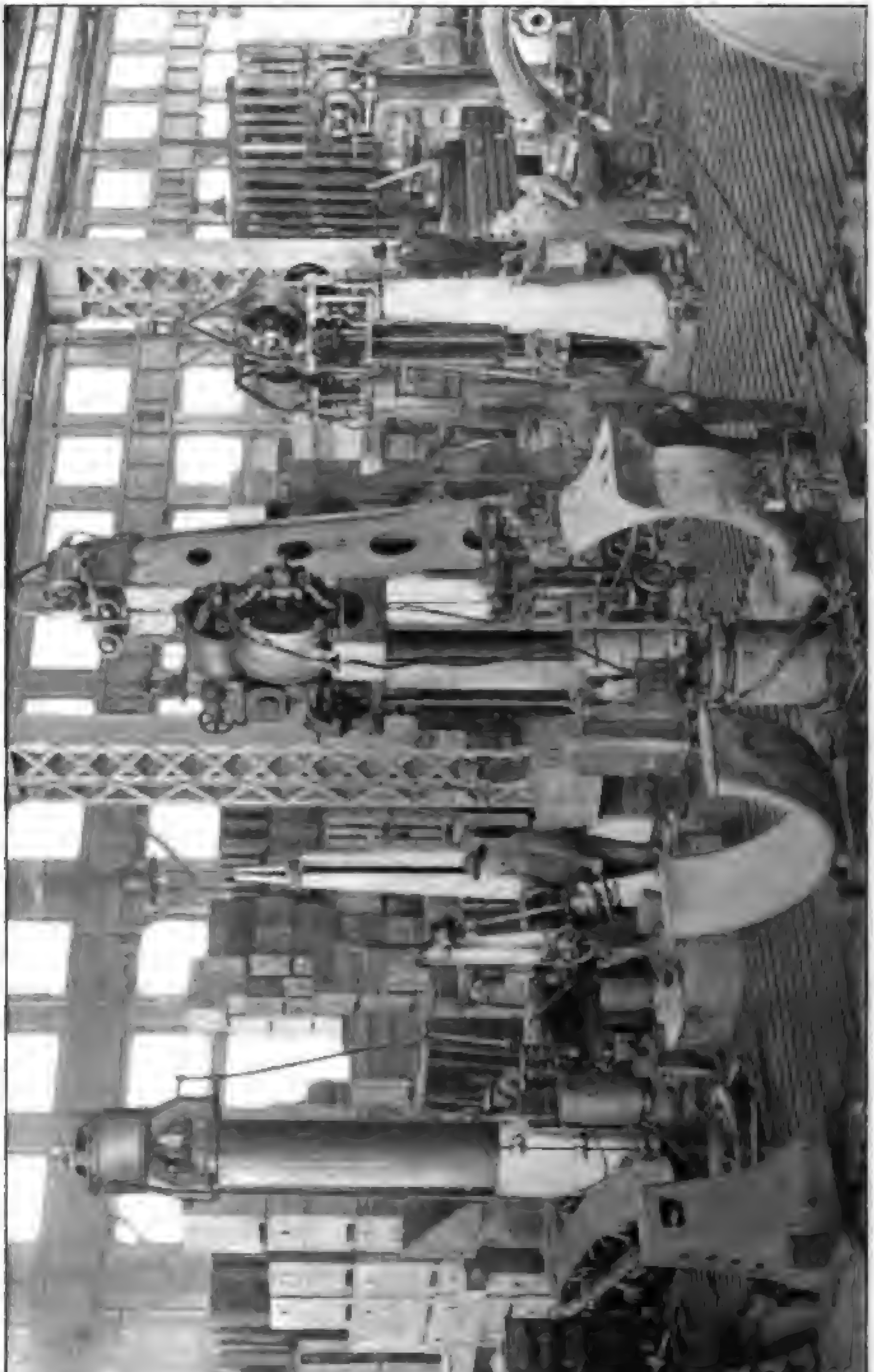
In all these modern creations of the mind of man, America has taken a prominent part, and the few statistics here given may serve to indicate the extent of this contribution to the progress of civilization in the twentieth century in which specialization in manufacturing has proved a powerful lever, more extensively employed in America than elsewhere, so that it may almost be considered as characteristic of American methods. The results prove the correctness of the statement made at the beginning of this paper that specialization is the key note of success in modern methods of economical production.

SOME ECONOMICAL ASPECTS OF THE ELECTRIC DRIVE

By F. M. Feiker

IN these days of close competition, the production of the best article for the least price is the end sought in all manufacturing. For that many a manufacturer spends sleepless nights, thinking out some way by which such and such a process may be cheapened in order that the net selling price per piece may be a trifle less than before. As the cost of labour and raw material advances, the inventor strives harder to evolve an automatic machine which often imitates so well the work of human hands that one has an uncanny sensation while watching its operation,—sure, steady, and ceaseless, with that unfailing certainty of action which we call mechanical precision.

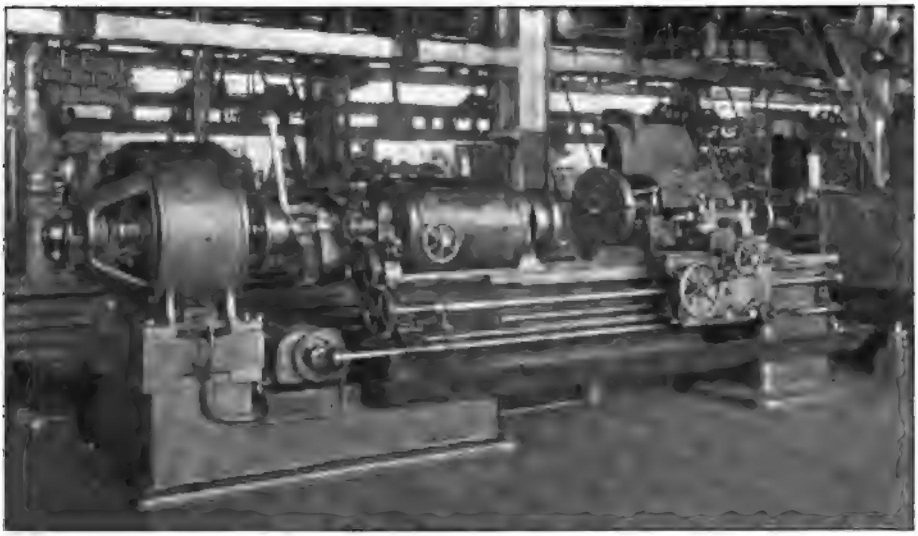
The machines which are thus substituted for much routine work are one of the aids in cheapening production costs. Automatic machinery, however, is not the only relief. Better methods of adapting and applying power to ordinary machine tools aid greatly in the contest between production cost and selling price. It is like the modern contention between heavy guns and armour plate. First a new steel which will resist the impact of any known projectile, then a new explosive or shell which will tear holes through a double thickness of the supposed invulnerable shield. The same is true of the production cost and selling price warfare, with production cost, like armour plate, ever on the defensive.



PORTABLE MOTOR-DRIVEN TOOLS IN THE BULLOCK SHOPS, AT CINCINNATI, OHIO, U. S. A., OF THE ALLIS-CHALMERS COMPANY

FROM A NIGHT PHOTOGRAPH AT THE LYNN, MASS., U. S. A., STEAM TURBINE SHOPS OF THE GENERAL ELECTRIC COMPANY, SHOWING THE ILLUMINATION OBTAINED WITH ELECTRIC ARC LAMPS AND CONCENTRIC DIFFUSERS

MOTOR DRIVEN TOOLS AT THE WORKS OF THE GENERAL ELECTRIC COMPANY AT SCHENECTADY, NEW YORK. NOTE THE CLEAR HEAD ROOM OBTAINED AS COMPARED WITH THE ILLUSTRATION ON THE OPPOSITE PAGE



A GOOD FORM OF ELECTRICALLY DRIVEN LATHE, THE MOTOR FORMING A RATIONAL PART OF THE TOOL. THE MOTOR IS OF WESTINGHOUSE MAKE. THE LATHE WAS BUILT BY THE LODGE & SHIPLEY MACHINE COMPANY, CINCINNATI, OHIO

Within the past few years electricity has entered into this industrial strife as a new factor, coming to the aid of the manufacturer and helping him to reduce his production cost. Electricity is not a sovereign cure-all for manufacturing diseases, but the application of the electric motor to modern machine shop driving is an effective antidote for many troubles. A glance at what this power will accomplish by way of assisting economical production is illuminating.

There are two classes of benefits accruing from the installation of the electric motor-drive in a factory,—those following directly, and a wider, less tangible, but none the less beneficial class of indirect results.

Perhaps the greatest point by virtue of which electricity gives its most efficient aid to the manufacturer is flexibility. In this regard it possesses a direct gain over any other form of power transmission, not only at the machine itself, but in the general layout of the plant. Starting at the engine room, we have a generator,—steam, water or gas-driven,—in itself the most efficient power transformer ever devised. In the larger sizes, 96 per cent. and even 98 per cent. of the power put into it is sent out as useful energy in the form of electricity.

Power in this tractable form is led to the switchboard. This is provided with switches and measuring instruments, and sectionalized, if necessary, so that one portion of the plant may operate independently of all the other portions.

If, in a belt-driven mill, any department has to operate overtime to catch up with production, long lines of heavy main shafting in other departments must run. With the electric drive, on the other hand, only such power is called for as is used and the highest operating efficiency is obtained.

On the switchboard are mounted power-measuring instruments which tell at a glance just how much power a certain room or section of the factory is using, or arranged to indicate the power consumed by a single machine. The importance of this point is easily seen, since the cost of power

for any operation may be known to the fraction of a penny. The exactness by which the amount of coal used in a mechanical operation is calculated is one of the niceties of the electrical system. The manufacturer can reduce his production costs to terms of coal and raw material with the greatest precision.

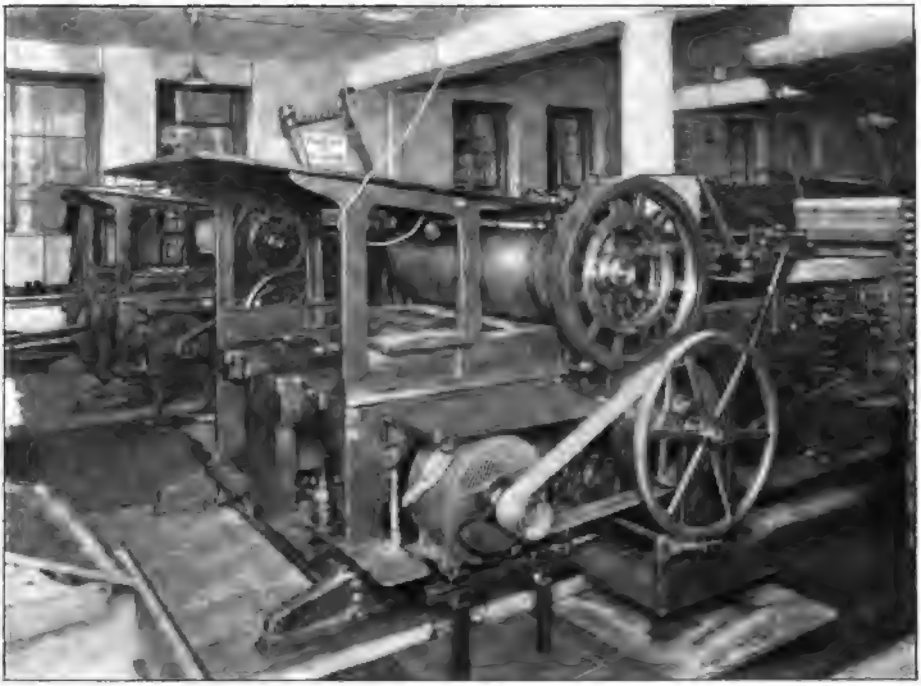
From the distributing switchboard, the power is carried by flexible conductors to the individual motors. Corners are no obstacle; quarter-turn belts that slip off on accidental reversal of engine are done away with; and the power is taken by the shortest, easiest path directly to the individual machine. If a group of small machines, requiring less than two horse-power apiece, is to be driven, it may be best to drive the machines from a short length of light line shafting. In that case a single motor of sufficient horse-power may be adapted for the work. Or it may be that the machinery is of such size as to be most economically driven by individual motors, in which event all the power used is applied directly.

In either case, the manufacturer saves the wastes attendant on the operation of long lines of heavy main shafting and belts. In the average case 50 per cent. of the power generated at the engine is wasted in line shafts and slipping belts. A better result follows only from constant care and attention to bearings, alignment of shafting, etc.,—in other words, by an approach to ideal operating conditions seldom realized in practice.

BELT DRIVING FOR SMALL TOOLS. THE OBSTRUCTION OF OVERHEAD ROOM IS MARKED

At the machine, the economy resulting from the use of electric power makes itself felt in a variety of ways. In some cases the motor, both in its position and action, is the physiological counterpart of the motor nerve centre of the brain, while the operator controlling the machine corresponds to the sensory nerve. This parallel could be carried with entire truth to delicacy of control.

The machine tool with the electric



WESTINGHOUSE MOTORS DRIVING CYLINDER PRINTING PRESSES

drive may be operated faster and more surely than with the old-fashioned belt-drive. Cone pulleys with slipping belts and speed changes with steps of 20 per cent. or 30 per cent. each, have given way to the direct-geared electric motor with a smooth, even, and wide variation in speed, always under the control of the operator. Time is saved by the operation in manipulating the machine. It is under his direct control, with the governing handle in the most convenient position. The tool is always operating at the maximum speed for efficient production, since the control and speed variation are adjustable with a great degree of accuracy.

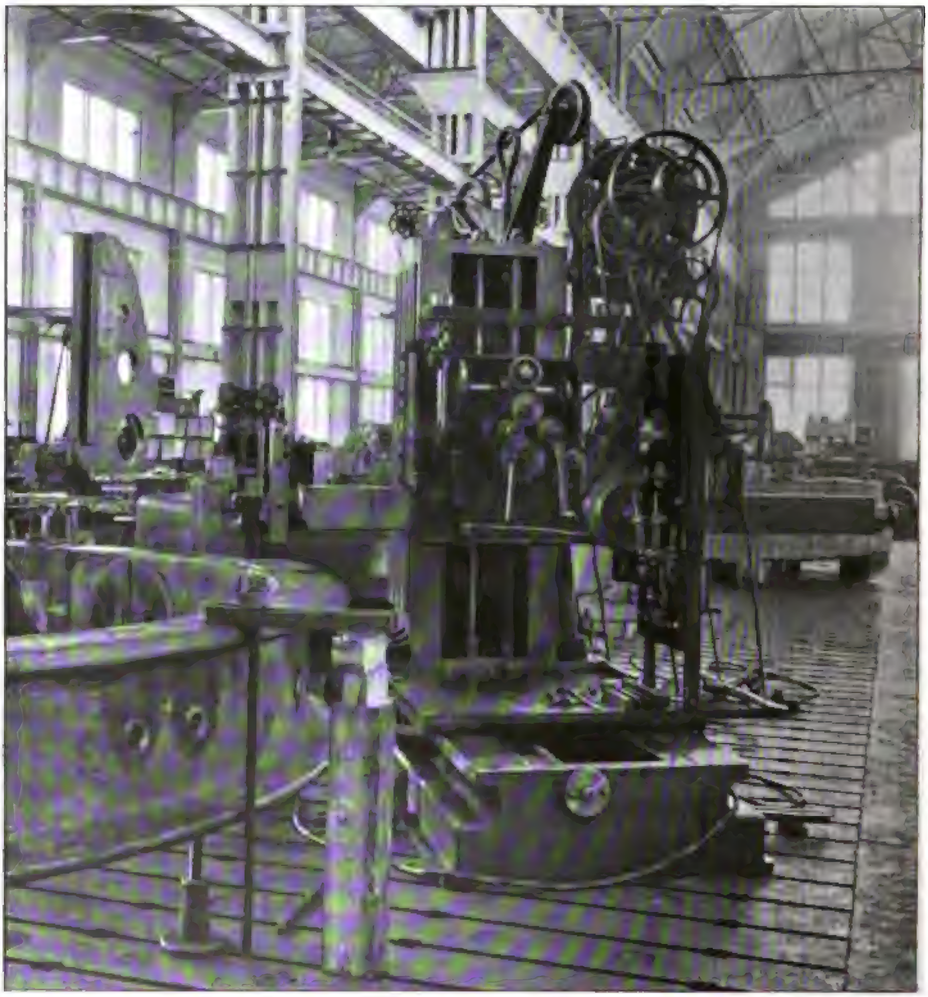
Control from a distance is another labour-saving feature of the electric drive. The ease and precision of this method is excellently illustrated in the modern rolling mill. Anyone who has watched the operation of the machinery in such a plant appreciates the adaptability of electricity. From the time when the steel fingers descend and grasp from the furnace a white-hot ingot, weighing tons, until the finished bars, rolled to size, cut off the proper length, and, still red, drop from the end of the shears, the entire operation is under the constant control of the man at the levers. In this case electricity not only replaces manual labour, but performs the work quicker, better, and more humanely.

Elimination of belts brings about other results. Suppose a number of machines have been installed with individual motors and the manufacturer discovers that by changing the sequence of operation a saving may be effected; all that is necessary is to move them bodily, without attention to power source, as the electrical connections can be easily made. With a belt-drive, however, the whole room would necessarily have to be rearranged, pulleys and belting changed, as well as line shafting.

Additions can be made without

overloading the line shaft or figuring on pulley speeds, which in many cases necessitate an additional jack shaft and more belts and wasted power in order to drive the machine at the desired speed. Such conditions are not imposed when the flexible electric motor forms the driving unit. With the belting eliminated, the open ceiling space secured is most advantageously used for a travelling crane, serving the rows of machines beneath. Large parts under construction can in this way be moved from one machine to another in the cycle of operations, or heavy work on the machines can be quickly placed in position and lined up for work.

Portable tools form another class of economical machinery made possible by the application of electricity. The introduction of such devices has probably quickened production as much as any one process entering into the construction of large mod-



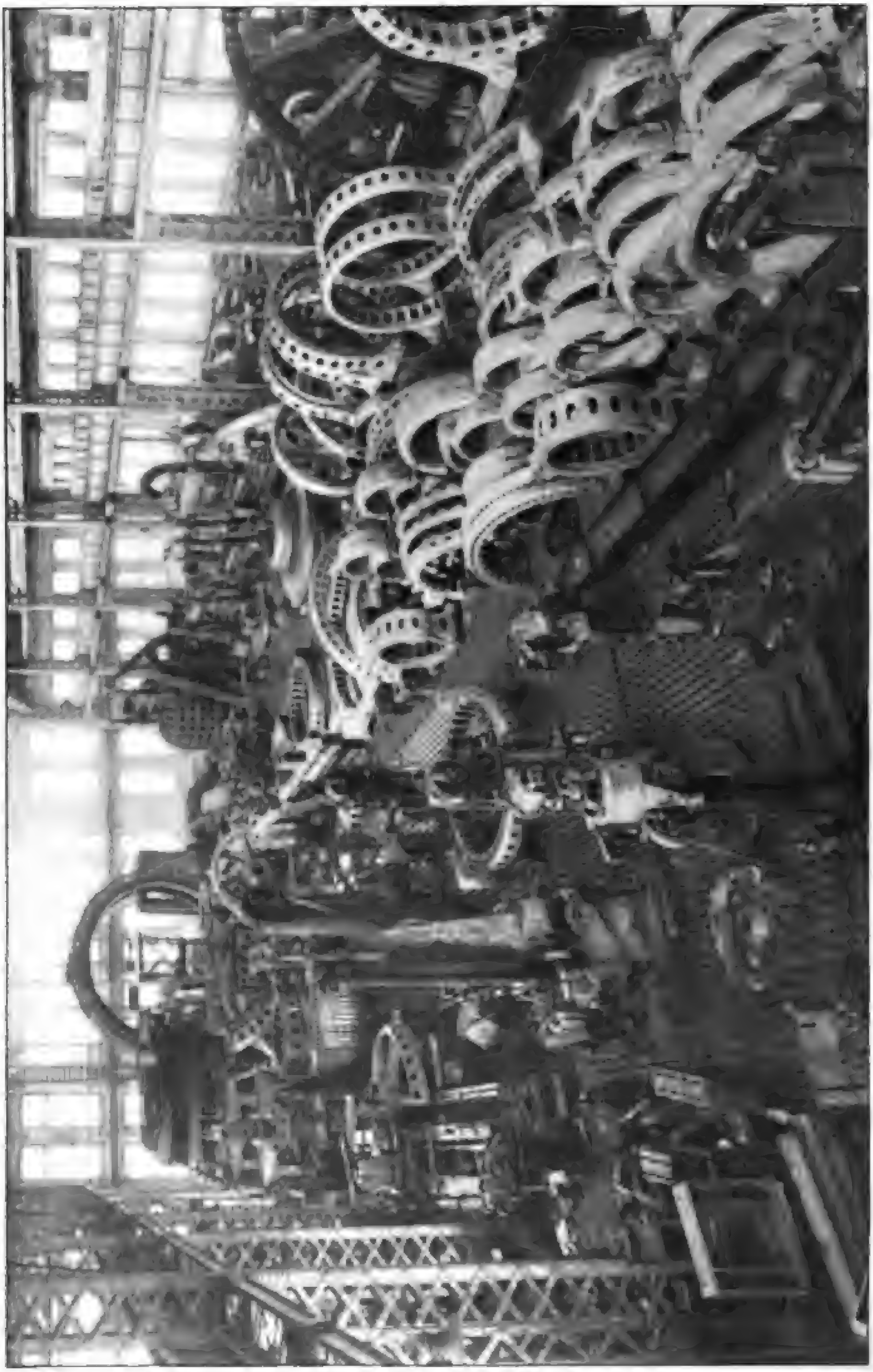
A PORTABLE MOTOR DRIVEN SHOP UNIT, CONSISTING OF A MOTOR AND SWITCHBOARD MOUNTED ON A COMBINATION SHAPING, MILLING, BORING, AND DRILLING MACHINE

AN ELECTRIC MOTOR NERVE CENTER. A SHEAR MADE BY THE CLEVELAND PUNCH & SHEAR WORKS COMPANY, CLEVELAND, OHIO, U. S. A., DRIVEN BY A GENERAL ELECTRIC MOTOR

ern machinery. Formerly the work was brought to the tool, but now the opposite system is widely used. The slotted iron floor of the shop forms an enormous machine base, upon which the work is lined up once for all, and bolted securely. With the crane, the tool with its motor and controlling apparatus, forming a working unit, are picked up and carried to the work. It is a common sight in a modern shop to see portable, electric-driven shapers, drill presses, and boring mills set up around a huge casting, each employed in its respective operation, simultaneously and with the greatest saving in time and labour.

The indirect benefits following the application of the electric motor to machine tool work which tend to decrease production costs are many. Absence of overhead belting means increased safety, cleanliness, light, and quiet. There is no oil to spatter over floor and work, no dust fanned about by whirling belts. Much danger attendant upon working about machinery is done away with, and the liability of accident, due to clothing or parts of the body catching in the machinery, is greatly reduced. Light is a valuable asset in any factory, but particularly where fine work or textile fabrics are produced. Even a naturally ill-lighted room gains materially with clear head space and becomes comparatively bright and open.

Indirectly artificial illumination gains in two ways. Electricity being the motive power, the use of the same energy for light, with all its beneficial results, is a natural se-



INTERIOR OF ONE OF THE ALLIS-CHALMERS COMPANY'S SHOPS AT CINCINNATI, OHIO. THE SLOTTED FLOOR FOR HOLDING DOWN PORTABLE ELECTRICALLY DRIVEN MACHINE TOOLS IS HERE WELL SHOWN

quence. Night work is carried on to the best advantage with this method of illumination, and with the clear head room the light is evenly distributed over the whole area with few shadows. Electricity is the modern light for this purpose. It is easily controlled, clean, and danger from fire is reduced to a minimum. With arc lamps large areas are flooded with clear, brilliant, white light.

In general, then, it is evident that the adoption of electricity not only enables better results to be obtained from the mechanical workers, but tends also toward the betterment of the employee's environment,—a combination best suited to give maximum production with minimum costs.

THE COMPOUND LOCOMOTIVE IN THE TWENTIETH CENTURY

By J. F. Gairns

THE merits and demerits of compounding for locomotives have for about thirty years provided subject-matter for innumerable engineering controversies, some of them heated, and most of them characterized by a good deal of nonsense on both sides; but whereas until the closing years of the nineteenth century it would have been most correct to describe the attitude of the world's locomotive engineers towards compounding as somewhat invidious, though even ten years ago compound locomotives were in use to the number of many thousands, with the commencement of the twentieth century it may be said that the era of the compound locomotive as a recognized feature of locomotive practice really opened.

To-day there is no country of importance where the compound locomotive is not in use to some extent, and they are employed to a considerable extent even in the smaller countries, and those not generally associated with progress. It is true that in some countries, notably Great Britain and Belgium, the compound locomotive is not generally in use, and in the former country it is in considerable disfavour (in both instances there is an interesting selection of experimental engines now on trial), while in Holland and Denmark it is practically unknown; but on the other hand, in France, Switzerland, Italy, Austria, Russia, and Scandinavia a very large proportion of recent locomotives are compounds, and in Germany and North America they are employed in very large numbers.

At one time the compound locomotive was in great evidence in South America and India, but of late years the proportion has somewhat decreased. Rather curiously, however, compound locomotives are in considerable use in countries such as Spain, Portugal, Egypt, China, Roumania and other Balkan States, and Asia Minor. The explanation of this is, that most of these engines are built by German, French, and American firms who are able to introduce their own systems.

When it is remembered that many of these locomotives are designed for the hardest and most important work, it will be realized that it is

both foolish and unwarrantable to argue, as is so often done in Great Britain in particular, that compounding is bad and the compound locomotive a failure. It may be, and probably is, a fact that the compound locomotive is not the miraculous machine that it is sometimes claimed to be, and many of the systems, particularly those of the early dates, possess disadvantageous features; but considered reasonably and with regard to practice, the compound locomotive of to-day is anything but a failure and unsatisfactory.

A notable feature of modern practice in compounding is that whereas in the earlier years the two-cylinder systems (these depended primarily and almost entirely on direct economy for their advantage) were most generally in use, at the present time the four-cylinder systems are most in favour. With these, except in two-crank four-cylinder systems, other advantages result from improved balancing, the division of work over two driving axles, more ready equalization of work between the high-pressure and the low-pressure cylinders (by adjusting valve-gears), and the possibility of providing for very great power, even if somewhat extravagantly, on occasions; and in both cases the work is distributed evenly on either side of the longitudinal centre line of an engine. It is, therefore, probably correct to state that the present satisfaction given by the modern compound locomotive is primarily due to related mechanical advantages, and secondarily to the direct economical advantages of compound working.

It is generally realized that the compound locomotive is to some extent wanting in "elasticity" for much varied work. A simple locomotive can be used in somewhat rough-and-ready fashion, and in the hands of a really capable driver can be made to do wonders with good efficiency. On the other hand, the compound locomotive is designed to depend less on the skill of the driver for its efficiency and more upon its own features; as a result, it requires more delicate handling, and really more skill (of a different character) on the part of the driver and fireman, while, if employed on work considerably varied from that for which it is designed, it is at a more or less serious disadvantage.

It can therefore be stated as fairly correct that the advantage or otherwise of compounding is directly dependent upon whether requirements are comparatively uniform and regular, or diversified, and whether working conditions are principally favourable or unfavourable to the efficiency of the compound locomotive.

On most railways locomotives are more or less frequently required to work unsuitable trains; in Great Britain, so far as the writer can ascertain, this occurs much more generally than in any other country. For example on many British railways it is quite common for the week's work of a first-class locomotive to be somewhat as follows:—

Monday.—A light, very fast express for about 180 miles with perhaps two or three stops one way, and a heavy train, nearly as fast, the other way, with perhaps several more stops.

Tuesday.—Stand pilot in reserve at the terminus, ready to go anywhere or do anything, either in assisting an overloaded train, taking the place of a disabled engine, or running special, time being usually filled in on shunting.

Wednesday.—A heavy fast or semi-fast train one way, and return with a fast or even a slow goods train.

Thursday.—Work a heavy stopping main line train, or one stopping at all important stations, on the outward journey, and return with a light "flyer."

Friday.—Work short-distance express trains, about two double journeys to a day's work.

Saturday.—Work a heavy, fast train out, and return with anything for which it can be used, or perhaps

attached in front of another engine for working home.

This is somewhat exaggerated as regards some British railways, but it is fairly correct for many of them; and when it is remembered that it is nothing unusual for goods engines to work passenger trains, sometimes fast ones, and tank engines to vary their work between fast trains with stops not too far apart, and local goods and shunting work, some explanation at least is provided why the compound locomotive is in general disfavour in Great Britain.

Yet such an explanation can be only partially correct, for Great Britain has not a monopoly of varied duties for locomotives, and therefore other explanations must be adduced to satisfactorily deal with the situation. The most important other explanations in the writer's opinion seem to relate (1) to the official attitude towards compounding; (2) the advantages or disadvantages of the particular systems employed; (3) the relative numbers of compound and simple engines; (4) whether drivers and firemen know how to deal properly with compound locomotives; (5) whether fuel is good or bad, or cheap or dear; and (6) whether it is considered best to employ simple engines capable of doing all that is required with fair average economy, or to employ locomotives which are more economical, but which cost more, at first, are a little more complicated, which require more skill in handling, and which may be handicapped to some extent on some descriptions of work.

As regards the difference in first cost, a good compound locomotive should soon make up for this, but on the score of complication it can be argued that the more parts there are, the greater is the liability of breakdown. Against this, however, is the equally pertinent argument that work can be better distributed over the working parts in the case of the compound locomotive, and, therefore, the liability of each part to breakdown, given equally satisfactory looking-after in both cases, is correspondingly lessened.

Until within the last few years a large number of two-cylinder compound locomotives were provided with automatic starting mechanism whereby live steam could be admitted to the low-pressure cylinder for starting, but as soon as there is pressure in the receiver, compound working commences automatically. In present practice, however, the general tendency is against automatic systems, though they are still employed to some extent. The systems now in use may be classified thus:—

(1) Those having special starting valves or devices for directing the steam passages and for supplying boiler steam at a reduced pressure (by a reducing valve or by wire-drawing) to the low-pressure cylinder; and (2) those in which non-compound working results whenever the valve gear is thrown into full, or nearly full, forward or backward gear.

Some of the modern two-cylinder compound locomotives are remarkable machines, and many of them are of quite recent build, but as a rule they are developments of older designs. Large numbers of older two-cylinder compound locomotives are still in use, but it is also fairly common for such engines to be converted to non-compound, particularly in Great Britain, the British Colonies, and some parts of South America.

Four-cylinder compound locomotives may be classified in several divisions, and their general characteristics may be briefly summed up as follows:—

Tandem Systems:—The employment of tandem compounds is very indefinite. They have been experimented with in many countries, but those where they are employed more or less extensively are Russia, Hungary, and the United States. Good work is done by them without question, but tandem systems are not in

general favour on any railways.

Two-Crank Systems Other Than Tandem:—The only system with this characteristic at all in general use is that for so long known as the Vauclain system, and introduced by the well-known Baldwin Works of Philadelphia for many thousands of engines employed in many parts of the world.

This system is peculiar for the fact that a high and a low-pressure cylinder are superposed at each side of the engine, the two piston rods in each case being connected to a single crosshead, and a single large piston valve controlling the steam distribution of each pair of cylinders.

This system has been superseded for the last two or three years by the Vauclain balanced system.

Four-Cylinder Balanced Systems:—These systems are very numerous. In all cases the cylinders are in line and at each side a high-pressure piston is always moving oppositely to a low-pressure piston, the cranks of each pair being 180 degrees apart and those of one pair being at 90 degrees to those of the other pair.

The systems are, however, diversified according to the relative diameters of high and low-pressure cylinders, whether two or four valve gears are employed, whether two or four piston or slide valves are employed, whether all the valve gears are adjusted in fixed relation or the high-pressure gear is adjusted with reference to the low-pressure gear, or both are independently adjustable, and according to the nature of the devices employed for using boiler steam in the low-pressure cylinders.

Four-Cylinder Divided and Balanced Systems:—The only difference between these systems and those just mentioned lies in the fact that two cylinders actuate one axle and the other two actuate another axle, the wheels being coupled.

Articulated Engines:—In these engines the wheels are arranged in independent groups, one group being operated by the high-pressure cylinders, and the other groups by the low-pressure cylinders.

Three-cylinder systems belong both to the days of the past and to the days of the present. The old Webb system has long been superseded and the slightly more recent Swiss system has also been superseded; but the Smith system is now the most essentially British system in use, and the engines designed according to it possesses a high reputation. As a rule the Swiss three-cylinder engines were designed so that the high-pressure cylinder operated one axle and the two low-pressure cylinders operated another axle coupled with it, but the Smith system is generally applied so that all cylinders drive one axle though on the Great Central Railway of England separate axles are driven.

Current Topics

REFERRING to the short article on "Seeing by Electricity," printed elsewhere in this issue, it may not be amiss to remark that the subject of seeing by electricity to a distance is not a new one. Several years ago the knowledge of the interest that would be aroused in scientific circles by the accomplishment of such a wonder suggested to several prominent electrical engineers of a humorous turn of mind, the playing of a practical joke upon some of their colleagues, which was carried out too successfully if anything. The jokers had caused it to be gravely announced that a device for the electrical transmission of sight had been invented, and a day and place were set for an exibition of the wonderful invention, and to this many of the prominent scientific people of London were formally invited. The particulars of the apparatus were not disclosed, but sufficient electrical apparatus and whirring machinery were provided to lend credence to the statements that electricity was a factor in the operation. At the appointed hour, the spectators were led one at a time into a small room where, on peering into a small aperture, the beholder could vaguely see the face of a friend whom he knew to be at the other end of the circuit in a nearby room. The professional standing of the perpetrators of the joke was such that no one questioned the reality of the exhibition at the time. And not until a serious account of the affair had been published in one or more of the leading technical journals, did it become known that the exhibition was a hoax and had consisted of a clever amplification of the well-known method of seeing around corners by properly arranged mirrors in right angular tubes. It will be readily understood that the subsequent comments of the technical journals that had been "taken in" were not at all complimentary to the perpetrators of the joke.

THE publication of Admiral Melville's article on "American Naval Organization and the Personnel Law of 1899" in our July issue gave us special pleasure because this magazine has always taken an active part in matters pertaining to engineering in the navies of Great Britain and America. It was in these pages that the first careful and satisfactory exposition of the then proposed American "Personnel Law"

was printed (in December, 1897), and we shall maintain our interest and our efforts until the question is settled,—and settled right. Progress in the two great Anglo-Saxon countries,—Great Britain and America—is along so nearly the same lines that it was only the occurrence of the expected when Great Britain put in force a personnel scheme in her navy very similar to that in the American navy. Human nature being much the same all the world over, it would have been astonishing if the "fighting engineer" had met with immediate favour in Britain while receiving rather cold comfort in America. In fact, matters are moving in much the same way in both services, and for the same reason,—the intense conservatism of the older executive officers.

AMONG the letters which have been sent to Admiral Melville, commenting on his article in our July issue, is one from a very able and experienced British engineer who has for many years been in close touch with the British navy and knows the whole subject of engineering personnel. Admiral Melville has kindly let us read that letter, and, as some points are of very great interest, we have secured permission to print the extracts which follow:—

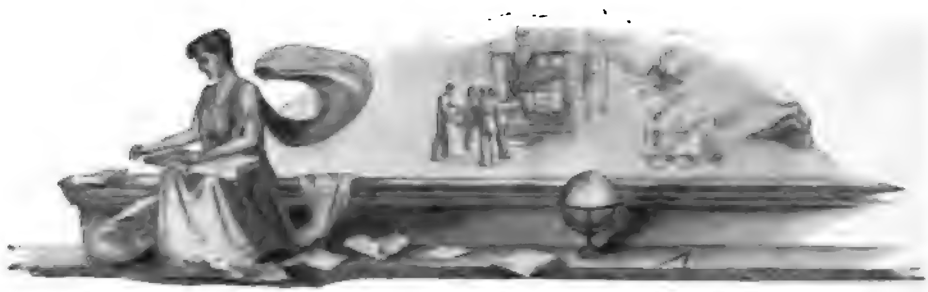
"I have just read your article in the July CASSIER'S, and I agree with every word you say. Please accept my congratulations and my thanks as an engineer for having put the case so plainly. What applies to your navy applies equally to ours. For years it has seemed to me that the old system was a degradation and a most undeserved one to our profession. What has filled me with astonishment and shame has been that the profession and science which alone keep every item and function of a modern navy efficient, should have had to fight so hard for recognition—not altogether for the personal satisfaction of the naval engineers themselves—but that the profession itself should have the credit it deserves.

"IT looks as if the authorities responsible for the administration of our navy were fully impressed with the great truth that every working officer should have an engineering training; it is, in fact, embodied in the new scheme of naval training which makes all naval officers engineers first, and then anything they may choose to specialize for afterwards. In a navy which is entirely dependent for its every function on some appliance of an engineering nature, it is essential that the basis of education and training for its working officers should be in engineering science. It appears to have been easy for the former young engineers of your navy to add the executive duties and become proficient deck officers. This is quite what I should have anticipated. That the converse has not worked so well is also not surprising, as I have long believed that an engineer can much more easily take on the relatively simple and mostly pleasant duties of the deck officer than the latter can qualify himself thoroughly as an engineer. Of course, this does not apply to those who are trained from the beginning for the enlarged field of the modern officer. I have no doubt, if we knew the whole story, we should find that much of this disinclination to become engineers has been fostered, rather than otherwise, by distinguished officers of the old school who hated to see the change, and who would like to relegate engineering and all concerned in it to the depths of the engine and boiler rooms, where they would never be seen, and it might be hoped they would never be heard asking for proper recognition of the profession which is one of the most important, if not the most important, in that fighting machine, the modern war vessel.

"I THINK our scheme of naval training should give us very good officers. It may need amendment later to insure sufficient expert knowledge in the varicus special lines, engineering, gunnery, and torpedoes. The most pressing point just now is that the engineers, who are not yet an integral part of the military branch, though they have been given military titles, should be merged in the executive as was done in your service. You state the reason for this very well in your article where you speak of the large number of men under the command of the chief engineer. As it is now, the engineers have the responsibility, but have not the legal authority to enforce discipline. A rather curious state of affairs may arise in the near future due to the fact that the young officers of the new plan are full executives, and, as such, have the right of command over the so-called civil branches of the navy. In securing their practical engineering experience at sea, these young officers must, of necessity, be under the control and direction of the older engineers, and yet legally have the right to command them. Such a situation is absurd and could never have developed, but for the prejudices and antipathy of the old-school officers to everything of an engineering nature. As you put it very clearly, the present change has come from the inside, but if it is not worked out properly by the service, it will be made right from outside—that is by the force of public opinion.

"IT is, perhaps, expecting too much from human nature to hope that the old type of admiral, as represented by many who received their training when engineering was in its infancy, and who have little or no knowledge of the needs of a modern navy, and little or no sympathy with the just aspirations of the engineering profession, would willingly concede to the new element a position which they themselves look upon as a sort of divine right. But, nevertheless, it is a pitiable and also an iniquitous situation that the real brain and workers of the navy should have to depend upon a semi-obsolete type of individual for the recognition which alone can make the efficiency of the service certain by granting a proper position and a proper scope for the exercise of its functions to the naval engineering profession, which nowadays embraces the whole navy."

AMONG the smaller savings in powei plant operation which are possible at all times, one or two may be mentioned as illustrating the simple ways in which waste can be cut down. In gas-engine plants the sensible heat of the exhaust gases is frequently thrown away. If hot water can be utilized in the plant—and in producer plants a small steam boiler is often employed for water-gas generation—a considerable part of this waste heat can be recovered. It is not a difficult matter to attach a feed-water heater to the gas-engine exhaust pipe, passing the water from the cooling jackets of the engine through the heater on its way to the boiler or other utilizing agency. Water which has been used to cool electric transformers has been utilized in the same general way. In one case the water consumption of the plant was reduced 50 per cent. by this course.



From Other Points of View

The Cost of Armour Plate

From "The London Times" Engineering Supplement.

THE cost of armour plating on a modern battleship approaches one-third of the total amount of the vessel. A vessel of the King Edward class costs about one and one-third millions, exclusive of armament, and Sir William White stated, in his lectures on "Modern Warships," that the armour cost about $2,000,000. According to the best information available, the average cost of that armour must have been about $500 per ton, while the thickness of the plates varied from 12 inches down to 3 inches or 4 inches. It is interesting to compare these approximate costs with those for the armour recently contracted for by the United States Navy Department, to be used in the battleships "Michigan" and "North Carolina." The total weight of armour per ship is about 3500 tons, the thickness of plates varying from about 14 inches to 5 inches or 6 inches. The Midvale Company offered to supply this armour at $345 per ton (average), the Carnegie Company at $370, and the Bethlehem Company at $380. It has been arranged to give the Midvale Company the order for one ship, and to divide the order for the other ship between the Bethlehem and Carnegie companies. These prices are lower than previous contracts, Midvale having quoted about $400 per ton, and the others $445, including a royalty of $25 per ton for the use of Krupp's patents. The latter statement throws an interesting light on the amounts which must be paid by the British Admiralty for the use of the Krupp patents, which, by the way, represent processes largely based on researches in which the late Sir William Roberts Austin and other of our metallurgical chemists took a leading part. According to the Navy Estimates, we are to spend about one and one-half millions for the current financial year on armour for ships now building; therefore the use of Krupp's patents, on the foregoing scale, probably involves a payment of over $375,000 in royalties.

The Midvale Company have no license from Krupp's concessionaires, but they have devised a process of manufacture that complies with the official tests; the other two companies use the Krupp processes, just as British manufacturers do. From the British point of view the important fact is that, if the preceding figures are correct, we are paying for armour about $150 per ton—roughly 40 per cent.—more than is being paid in the United States for armour of equal

quality. On a King Edward type of vessel this involves an increased expenditure of from $500,000 to $600,000.

Naturally the inquiry arises why armour should be more costly in Great Britain than it is in the United States. Five first-class firms undertake the manufacture here. Their united output is said to be equal to the production of 40,000 to 50,000 tons of armour per annum. This far exceeds present demands, and doubtless represents a huge capital expenditure not at present fully productive. It is only fair that firms which have shown such enterprise in a special branch of manufacture should have their reward; but looking to the dividends declared in recent years and to the prices paid by the Admiralty as compared with American prices since the Senate inquiry, their enterprise and expenditure have doubtless obtained the reward they deserved. A point has been reached, however, if the foregoing statements are correct, where British armour-plate makers ought to imitate American competitors, and lower their prices. In the United States serious consideration was given some years ago to the establishment of a government armour factory. Even now the idea finds favour in some quarters, although the action of Midvale has made it less urgent, and the trust is being fought by a private company instead of by a State establishment. Whether a trust exists here or not may be disputed. What is obvious, however, is that prices are kept at a high standard, and that practical uniformity of quotation exists among the five firms.

Blasting in Large Cities

By R. W. Raymond in "The Engineering and Mining Journal."

RECENT numerous instances of damage done to persons and property by blasting warrant a more vigilant supervision, not only of the handling of explosives, but also of the methods of excavation involving their use. So far as danger to human life is concerned, it may be sufficient to secure care and competency on the part of those in charge; but with regard to the perpetual nuisance of noise, and the peril in which buildings and foundations are involved, something more should be, and easily can be done, namely, the unnecessary excessive use of explosives should be prevented. The public now submits to the shocks and dangers of heavy blasts, under the impression that these evils are inevitable. But it is perfectly practicable to make excavations and drive tunnels through rock without such catastrophic performances. In tunneling, for instance, deep holes are usually bored at the face, and heavy charges of explosives are fired in them, with great loss of useful effect, due to the disadvantageous direction of the holes. If a vertical cut were made in the center of the face, small holes on both sides, parallel to the cut, would give with light charges a full theoretical effect, "throwing" toward the center-cut, and wasting neither energy nor noise in pure, useless mischief. The thing has been done. Manufacturers of rock drills are ready to furnish machines which will make the center-cut; and the process, skillfully directed and manipulated, need not be more expensive in the aggregate than the present orgy of misdirected power. Even if the direct cost were a little higher, it would be more than compensated by the immunity from expensive accidents.

If I am correctly informed, this obvious improvement, while it has shown itself to be both practicable and capable of reasonably economical application, has encountered a passive resistance, shown in lack of loyal co-operation, on the part of both contractors and workmen. Engineers do not like to quarrel with contractors over points not definitely fixed by specifications; contractors do

not like to quarrel with labour unions; and labour unions fight, on general principles, all novelties or economies which do not actually increase wages. So there we are; nothing will move all parties but a legal requirement.

Oil and Boilers

From "The Engineer," London

THE Scotch boiler is very far from being superseded. In good hands it has been modified sufficiently to keep step with the latest developments in marine-engine construction. It can carry pressures of as much as 220 pounds, which is quite enough for even quadruple-expansion engines. When fitted, as on most modern lines, on Howden's system, the coolest possible stokehold is secured, radiation from the ashpits being entirely and from the boiler fronts almost altogether prevented. In the matter of repairs and economy it has proven to be so satisfactory that none of the great ocean shipping companies has seen its way to substituting some other form of generator for it. There is, however, a weak place, and that is the adverse effect which a comparatively small quantity of oil has on the furnaces. It is a commonplace of marine engineering that an almost imperceptible coating of oil on the furnace crowns will cause them to overheat and come down,—the reason why has not been conclusively settled. So far as is known, the oil prevents contact between the water and the metal; and absolute "wetting" of the metal is essential to the transmission of heat rapidly and regularly. An excellent illustration of this is supplied by soldering with a "bit." If the surface to be soldered is not clean, the melted metal will not "wet" it, and the surface remains cold; the heat of the bit is not transmitted to it. If the surface has been cleaned by a suitable flux, as, for example, resin, the heat of the "bit" is freely imparted to the tin plate through the melted solder, and union is effected at once. The essence of success in transmission of heat is good contact. Oil prevents it, and overheating takes place. The action of oil is, perhaps,—but this is not certain,—intensified by the presence of lime, oxide of iron, and magnesia, and such like, always found in a boiler. We may add here that sometimes analysis fails to detect oil in the thin deposit on a collapsed furnace crown. This fact is no evidence that the oil was not there, the over-heating vaporizing the oil, and driving it away.

So well is the nature of the risk incurred now understood that oil is hardly ever put into a cylinder. The impermeator has gone to the scrap heap long ago. Although not put in, oil gets in nevertheless. It is not possible to keep piston-rods in order and cool without lubrication. The rods are swabbed from time to time. It is an interesting fact that if steam in motion gets access to oil, it will take it up in much the same way that wind will draw up water. The steam in the cylinder takes the oil off the rod and distributes it through the engine, whence it proceeds with the exhaust steam to the condenser and hot well, from which it is conveyed to the boiler unless stopped on the road. The stopping apparatus is a filter. There are many filters available. For the most part they act as strainers, the oil passing through toweling or sponge, by which it is caught, or supposed to be caught. The process is much better in theory than in fact. A marine engine of only 1000 horsepower will use at least 1500 gallons of water per hour. A modern liner of moderate size will use 15,000 gallons per hour. The efficient extraction of oil from quantities so large cannot be effected without comparatively big filtering surfaces, and the cloths must even then be frequently changed. But this is not the worst of the matter. Many oils good in other respects emulsify with

water under the churning action of the pumps. Now, unfortunately, no means exist of filtering out emulsified oil from water. Emulsification consists in the breaking up of the oil into globules so tiny that they can scarcely be seen under a microscope. They will pass freely through any practicable filter, and finally settle on the steel plates in the boiler, apparently taking furnace crowns for choice. So far, the only way out of the trouble lies in using oils which will not readily emulsify with water. Mr. Morison, of Newcastle-on-Tyne, an eminent authority, in the course of an excellent paper on boiler furnaces, read last year before the North-East Coast Institution of Engineers and Shipbuilders, said:—"It is not the very high-grade mineral oils which give serious trouble in boilers, but cheap, low-grade oils, and particularly the oils used in lubricating the auxiliary engines and deck machinery. These oils, emulsifying with the feed-water, cannot be filtered out, unless the water be first chemically treated; so in ordinary practice they are discharged into the boiler, and there become a source of inefficiency and danger. A cylinder oil for marine engines should be of a known brand, preferably obtained direct from a known manufacturer, and the feed-water should be filtered."

There is another side to this question. When a furnace is overheated it will come down. But what does overheating mean? The word is very vague. Let us suppose, however, that it means a dull red heat. We can picture a furnace so made and of such materials that it would not undergo permanent distortion, much less collapse or breakup, even under a heavy pressure. There is reason to believe that the very overheating would volatilize the oil and break off by expansion any lime on the plates. They would be cleaned automatically, and contact would gradually be restored between the plate and the water, and the plate would cool down and no harm be done. Furthermore, it is plain that some kinds of furnace will be dangerously overheated sooner than others. Thus, we might have a plain furnace which would not be very stiff to begin with, and being equally overheated throughout, would easily come down, while a corrugated furnace would be originally stiff, and, in addition, the overheated portions would consist of rings at the bottom of the corrugations, while the tops, being less liable to hold deposit and further away from the hot flame, would act as strengthening rings and hold up the crowns. This is a condition which has not received all the attention it deserves, though it has not been overlooked. There are many degrees of overheating, and it is indisputable that some kinds of furnace will easily bear up under temperatures which are fatal to others.

But besides shape, there is yet another element which has, so far, received no consideration whatever in the construction of marine boilers. A few experiments have been made to test the tensile strength of steel when heated to various temperatures. These have been intended rather for academic than practical engineering purposes, because, it has been pointed out, it is not supposed that highly-heated metal shall ever be subject to stress. The argument does not hold good of boilers. The shells and stays are never raised to a temperature at which they sensibly lose tensile strength, which may be taken at or about 650 degrees F., while that of 200-pound steam is only 380 degrees F.; yet in a boiler furnace the metal is in compression, not tension, and it is very probable that some steels will endure greater compression stresses when heated than will others. Tool steels, for example, will go on cutting even when red-hot, and we can imagine a flue made of high-speed tool steel which might be heated to redness without collapsing. Of course, we do not

suppose that tool steel furnaces can be made, but between tool steel and 28 or 30-ton steel there is a very wide gap, and it may yet be found possible, when once attention is directed to the subject, to produce a steel which, with other good qualities, would possess useful endurance when overheated. Vanadium steel may, perhaps, one of these days, help in this direction. In any case, we think that a full discussion of the behaviour of various steels when heated and under pressure would be useful and interesting. The field of research in this direction is open. That it has not been more worked is mainly due, first, to the belief that little practical advantage would be gained from an inquiry of this kind; and, secondly, from the assumption that the relations between compression and extension are independent of temperature, so that if the tensile strength of a given specimen was known at any given temperature, then its compression strength would be the same. We venture to think that there is not sufficient justification to be found for the rigorous application of either assumption.

Caisson Disease

From "The Evening Post," New York.

RECENT autopsies performed upon human beings killed by caisson disease indicate that the "bends" is caused by air bubbles in the blood, as those bubbles have been found in the heart, blood vessels, and various tissues and organs. Air bubbles may seem very harmless and it may be asked how they are capable of producing such profound disturbances and often death.

The realization of the serious consequences of air in the circulating blood is as old as Galen, and the danger of allowing air to enter certain veins in the course of surgical operations is guarded against by modern surgeons. If by any chance air as a bubble—that is, in contrast to absorbed or dissolved air—is in the circulating blood stream, it acts like a foreign body. The bubble may pass along for a distance, but at some point it will block the circulation of the blood by obstructing a small artery. Should the air bubble lodge in a vessel of the brain through which the blood passes to nourish some important center, as that which controls respiration, then the brain center would at once cease to function. The individual stops breathing and death ensues. The same is true of an air embolus in the heart. But if the circulation to centers that are not vital is impeded, the other symptoms of the disease are manifested, pains in the limbs and joints and various degrees of paralysis.

In the less severe forms of "bends," complete recovery of health is not unusual, because in the course of a little time the air is reabsorbed into the tissue fluids, and those parts which have suffered as a result of starvation in having the blood stream cut off from them are again restored to normal. Only in the case of the nervous system, where regeneration of injured tissue is especially difficult, do permanent injuries result.

If the man who has been in a caisson for several hours under a pressure of two or more atmospheres passes quickly through the decompression lock—so quickly that the air is not held in solution in the blood, but escapes in bubbles in the tissues—this free air causes, if not death, a train of severe and dangerous symptoms. Physicians have been somewhat slow in accepting the explanation of "bends," probably because the facts seem more tangible to a physicist than to one trained to medicine, and also because the observation of cases in the hospital has revealed little in explanation of the disease and nothing as to means of treatment. In fact, "bends" is a condition which need almost never occur.

Leonard Hill and Macleod, two physiologists of the London Hos-

pital, have repeatedly placed monkeys in a small caisson and subjected them to a pressure of eight atmospheres (117.6 pounds per square inch) without any apparent injury to the animals. These investigators, however, allowed two hours for decompression from this high pressure, which is much more than is ordinarily used in any engineering construction. It is the belief at present that at least fifteen minutes for each atmosphere of pressure should be taken in order to be within the bounds of safety, but whether this precaution will ever be rigidly observed is questionable; and it would be safe to say that the men themselves, as much as any construction company, would object to a period of a half hour spent in a decompression lock, when there is a possibility that no harm would come if only five minutes were allowed for the operation.

Line and Station Protection Against High Potentials

G. E. Palmer, Before the Association of Electric Lighting Engineers of New England

ALMOST any line can be protected against high potentials if sufficient insulation and enough protective devices are installed; but it is, after all, more feasible to try to protect the weak spots in a system than to attempt to insulate or protect it all on the same scale of investment. The majority of so-called static breakdowns in cables are due to defects which follow short-circuiting. The lightning arrester is merely a weak point in the system purposely made weak, and it should in all cases permit line discharges to continue without going out of service or without permitting arcs to form. Zinc, antimony, cadmium, bismuth and mercury are ideal metals for use as electrodes in lightning arresters, for their vapour does not perceptibly decrease the resistance of the gap. The ideal construction should allow equal opportunities at all points for the discharge of high potentials.

A very significant phenomenon was noted in a telephone circuit which Mr. Palmer had installed. The circuit was about 100 miles long and the work in hand was the rebuilding of an old line. It was found that when new, clean insulators were used, the line was very noisy and almost too poor for service. The insulators of the old line were put back, dirty from their former service, and the line at once became one of the best in the whole exchange. The distributed leakage took care of the static discharges without the least trouble.

Mr. Palmer suggested the construction of a special insulator which would offer a high resistance path to earth, constituting a "crack" in the electrical system. The idea would be to dip the insulator into a metallic solution before glazing it, mounting it in service upon iron pins with a common metallic ground connection. The metallic film would not act as a conductor in the ordinary sense, for its resistance might be as high as 50,000 ohms, but it would be able to dissipate abnormal discharges without punctures.

Trouble with Moist Air from an Air Compressor

From "The Engineer's Review."

AIR compressors, as most engineers know who handle them, sometimes cause a good deal of trouble. The plant that I have charge of has been running about two years, and among a lot of first-class apparatus a new compressor was installed, of the compound type, having cylinders 18 inches on the low side and 12 inches on the high side with a 12-inch stroke, belt-driven.

When I started this compressor everything ran all right, but the air was very moist, sometimes getting so

bad that it could not be used on the air hoist in the foundry or on the pneumatic drills in the machine shop, and it was up to the engineer to furnish dry air. The receiving tank would sometimes fill up to one-quarter of its capacity with water.

One Sunday I took off the heads and found that the high-pressure cylinder was full of water, while the low-pressure cylinder was dry. I then examined the cooling chamber which is located between the low and high-pressure cylinders, and found that full of water also. Then I began to see light.

The trouble was caused by the drain pipe from the cooling chamber being connected into the main drain pipe in the engine room. This main drain pipe received the water from all the pumps, condensers and engine drips in the plant. The compressor was provided with a governor which was placed on the air intake pipe. When the ball on this governor is down, the compressor takes air and discharges it until the desired pressure is obtained. Then the ball rises, the intake valve closes and the compressor runs under a high vacuum.

My trouble was that every time the compressor ran under a vacuum, when the valve on the drain pipe on the cooling chamber was open, it drew all the water that was in the drain pipe into the compressor, and from there it found its way into the receiving tank and caused trouble.

I disconnected this pipe from the main drain pipe and the air has since been perfectly dry, excepting in rainy or real cold weather, when it may get a little moist, but not enough to cause any great amount of trouble.

HENRY LATHAM DOHERTY

A BIOGRAPHICAL SKETCH

By John Craig Hammond

THE man who invents and creates, the man who improves on old methods,—a man who is a leader is the man worth while.

To be a leader, to put away old methods and follow some untried path is to bring down a certain amount of adverse criticism. If the man can not weather the fault-finding until his method is demonstrated to be a practical one, he will never make much headway.

Henry L. Doherty is the type of a man who is a leader. He is a man who refuses to accept any set rule for life until he has tested that rule and found he can not improve upon it. He wants the new way, the undiscovered way of reaching an end. He will follow it if, after due deliberation, he makes up his mind that it is practical. He is the type of man who thinks ahead. Because men who have made a success of life in the past followed such and such a rule, it is not enough for Mr. Doherty that he should follow it. Maybe there is a better way; if there is, he wants to find it. Like all men who have made any success of their natural talent, he has the solid foundation for building on the right kind of rules.

He closely follows the rules of life of honesty and hard work. But with all his tremendous duties he is like other folks of flesh and bone. He can laugh, he can play, he smokes,—he likes the society of friends.

Mr. Doherty is one of the younger generation of men to invade Wall

street, but he is not like the accepted type of Wall street man. He is not a speculator on the market. He is a speculator to this extent,—he speculates on his ways of doing business, his experience and ideas, and he has yet to report a failure.

In the towering hive of humanity at No. 60 Wall street, New York, Mr. Doherty has a suite of offices that take up half of the fourteenth floor. There it is that he directs his investments in the gas and electrical field, surrounded by an organization of engineers, accountants, and attorneys that he has been building up for years. In more than a dozen cities he has men who are keeping constantly in touch with the progress of the public utility corporation business,—experimenting, investigating, carrying out his suggestions and ideas.

A year ago it was impractical to approach Mr. Doherty with a request for his photograph. His name in cold type would cause him to shudder with fear. And still he numbers newspaper and magazine writers among his best friends. In fact, among the forty odd clubs of which he is a member, three are press clubs.

"Why not let me write a story of your life?" a newspaper friend said once upon a time.

"Wait until I accomplish something," was the reply.

"But you have accomplished something. You have grown from a boy to manhood, self-educated, self-made. You became a gas engineer, an electric engineer. You are president of gas and electric companies, you own companies, you are vice-president and consulting engineer of the American Light and Traction Company,—you are head of the firm of Henry L. Doherty & Company, bankers; you are a Wall street magnate—"

"Speaking of opals," broke in Mr. Doherty, "I have an extra odd one that I have just added to my collection of stones. It is yours, my dear fellow, if you will please forget what I have done and tell me what I have not done. That's of more importance."

And there the effort of getting the story of the success of Henry L. Doherty ended for the time.

"If I had not become interested in the gas and electric business, I think I would have made a newspaper man," Mr. Doherty said recently. "I liked the business—I like the newspaper men. They represent to me one of the highest types of men we have—that is, if they always follow the rule they should,—do the best they can. Like some engineers, they may cheat themselves at times. We marvel at the progress of electricity—I marvel at the great advancement made in the world of letters."

Mr. Doherty started his career in the gas world at Columbus, Ohio, under the tutelage of Emerson McMillin—a man who, Mr. Doherty claims, is the best gas man in the country. There may be better gas engineers, better electrical engineers than Mr. Doherty, but there is no better combined gas and electrical engineer.

In association work of gas and electric companies he has been one of the pioneers in advancing the cause. The Doherty rate for charging for gas and electricity and the Doherty new business methods have been up for discussion during recent years. The Doherty gas calorimeter, furnace combustion regulator, tar extractor, gas purifier, gas air compressor, and on to a score and one other inventions came from the fertile brain of Mr. Doherty.

While still a young man, Mr. Doherty has spent more than twenty-five years in the gas and electric business. He is never satisfied with what he does or has done; he is constantly striving to improve and to advance. For a year past, in addition to giving his time to managing and operating nearly a score of plants and gas works, including one street railway and water company, he has been turning his attention to the

buying of new properties. He has a following of Western bankers and men of money who take his word without question.

Recently Mr. Doherty acquired a new property. The purchase price was over $1,000,000. The entire money for securing this property was subscribed by friends.

"I have a good property in sight. Will take a million. How much stock do you want?" was the question sent out by Mr. Doherty.

One man answered: "What and where is the property? Count on me for $50,000 if O. K."

"Can't tell you about property now. My word goes with it."

"Give me $100,000 worth if your word goes along," came back the answer.

That true little incident indicates the blind confidence his friends and associates have in his ability and judgment.

"When you make a friend, keep him. You can keep him only by being right and fair," is the motto on which Mr. Doherty is doing business.

"The electrical business—it is old to say it—but we are only getting started," said Mr. Doherty. "To-day the best indications that this is true are the constantly growing followers of public utility corporations. Management has become a science in these stations—even as great as service.

We have demonstrated that we must keep in touch with the public, deserve the good will of the public by being fair and giving them the best service at the least possible cost. A central station run on that principle has no reason for failure."